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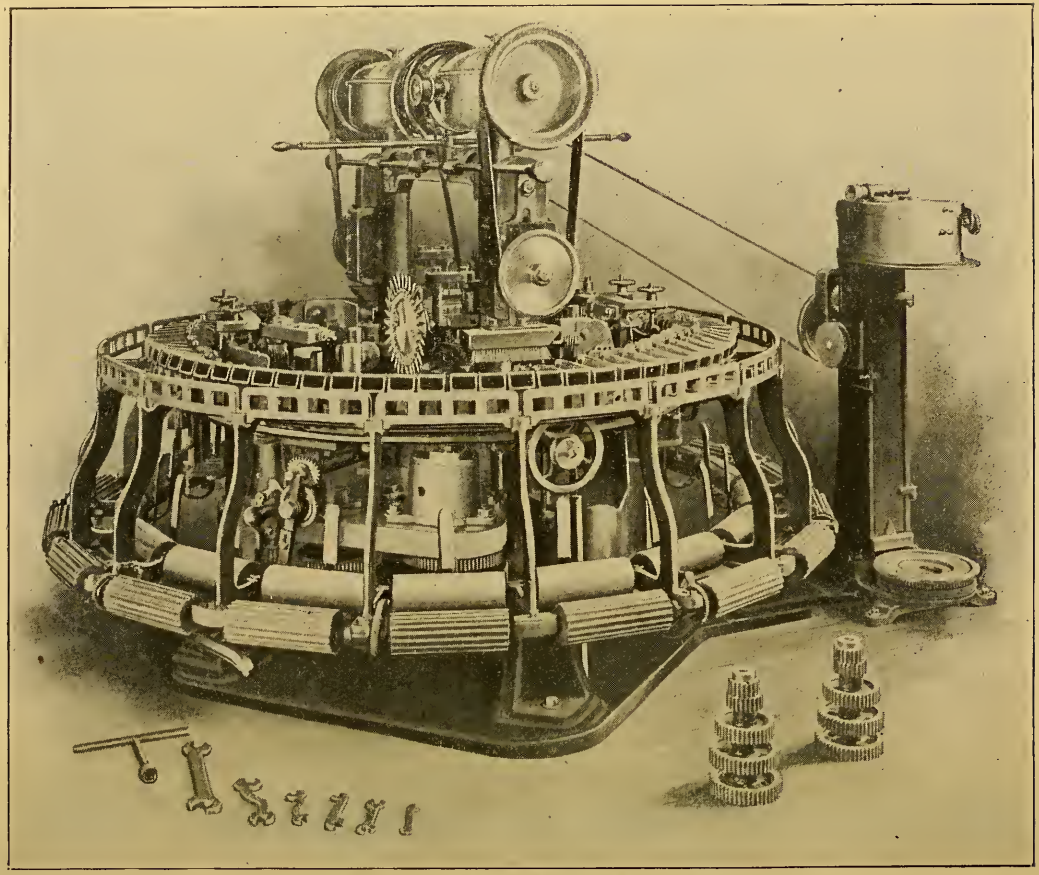

WOOL COMB FOR COARSE, MEDIUM AND FINE WOOLS

Crompton & Knowles Loom Works

Woolen and Worsted Spinning

362

A Complete Working Guide to

MODERN PRACTICE IN THE MANUFACTURE OF WOOLEN AND WORSTED YARNS AND FELT, INCLUDING THE SOURCES, NATURAL PROPERTIES, GRADING, AND CLEANSING OF THE RAW MATERIAL, AND THE MACHINERY AND PROCESSES OF FACTORY WORK

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Superintendent, Abbott Worsted Company
Graniteville, Mass.

ILLUSTRATED

CHICAGO
AMERICAN SCHOOL OF CORRESPONDENCE
1909

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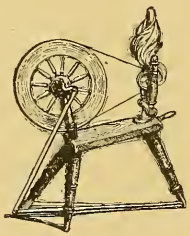
Foreword

THE Textile Industry has shared to such an extent the modern tendency toward specialization, and has been marked by the development of such a multiplicity of types of machinery and special mechanical and chemical processes, that its various branches to-day constitute in reality distinct though closely related arts. It is the purpose of the present volume to furnish not only a comprehensive reference work on the fundamental branch of Woolen and Worsted Spinning, but a working guide to all details of modern practice in the manufacture of woolen and worsted yarns, embodying the latest approved methods as developed in the best American mills and based on a careful study of the best modern types of textile machinery.

¶ This volume is especially adapted for purposes of self-instruction and home study. In its preparation, special stress has been laid on the *practical* as distinguished from the merely theoretical or descriptive form of treatment of each topic; and the utmost care has been used to create a work perfectly adapted not only to meet the requirements of a manual of practical instruction for the beginner in textile art, but also to serve as a reference work replete with information and suggestions of great practical value to the most advanced and experienced textile worker.

¶ The method adopted in the preparation of this volume is that which the American School of Correspondence has developed and employed so successfully for many years. It is not an experiment, but has stood the severest of all tests — that of practical use—which has demonstrated it to be the best method yet devised for the education of the busy workingman.

¶ For purposes of ready reference, and timely information when needed, it is believed that this volume will be found to meet every requirement.



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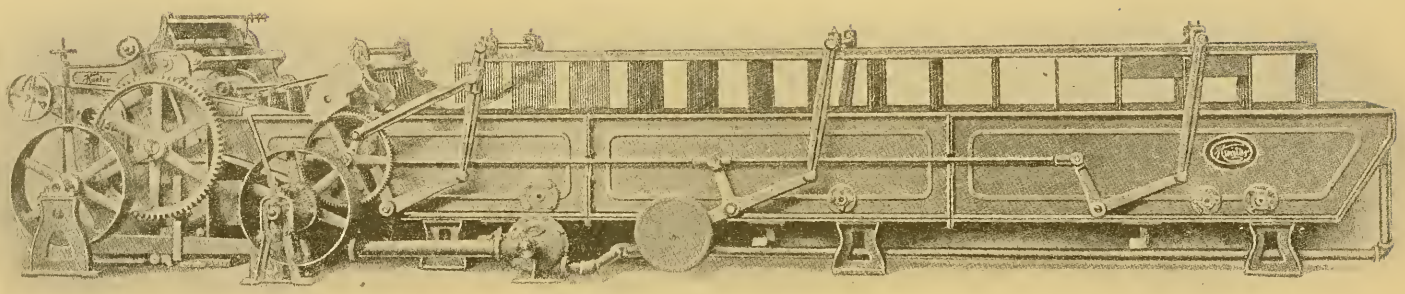


AUTOMATIC WOOL WASHER WITH IMPROVED PARALLEL RAKE MOTION

The James Hunter Machine Co.

WOOLEN AND WORSTED SPINNING.

PART I.

WOOL AND HAIR PRODUCING ANIMALS.

To have a comprehensive knowledge of the woolen and worsted industries, and to understand the nature of wool, hair and other fibres used in the manufacture of fabrics or woolens, and to be acquainted with the various processes and operations, and the principles that underlie them, it is necessary to know something of the animals from which wool and hair are obtained. One should also have a knowledge of the different climates and countries where certain species of sheep, goats and camels are found.

The sheep is a ruminant mammal, domesticated in a great many varieties, and one of the animals most usetul in this respect. The male is the ram, the female the ewe, and the young the lamb. The chief countries from which comes wool are England, Australia, the United States and Territories, New Zealand, Germany, France, Spain, Cape of Good Hope, Canada, Austria, La Plata, East Indies, Van Dieman's Land, Russia, Sweden, Norway, Denmark, Holland, Belgium, Switzerland and Italy.

If sheep are allowed to ramble at will on moors and mountains, without any care, coarse fibres or hairs appear among the wool of the fleece. This occurrence in the fleece of the domestic sheep is rare; for when the sheep is domesticated the rank or coarse hair gradually disappears, and the soft wool around the roots, which is hardly visible in the wild animal, becomes singularly developed. When these strong hairs are seen in domesticated sheep it is always regarded as a defect in sheep farming.

The Mouflon is a probable ancestor of some at least of the domestic sheep, probably those with short tail and crescentic horns. The Mouflon is a species inhabiting the mountains of Southern Europe, as in Greece, Sardinia, Corsica, Barbary, and also Asia Minor. The fleece is very short and coarse, more like

hair than wool; but the most singular and striking characteristic is the very long hairs with which the anterior parts of its body and legs are covered. Hairs from six to seven inches long spring from the three lower quarters of the foreleg as far as the shank on the anterior, posterior and external sides, and hang down nearly to the ground. On the throat there is a band of hairs varying from six to thirteen inches in length. These features form a very remarkable kind of ornamental appendage.

Divisions. Sheep are commonly divided into the long and short wooled varieties. Some have been described as middle-wooled sheep. This character of length of staple is accompanied by traits which are worthy of attention: thus the long-wooled

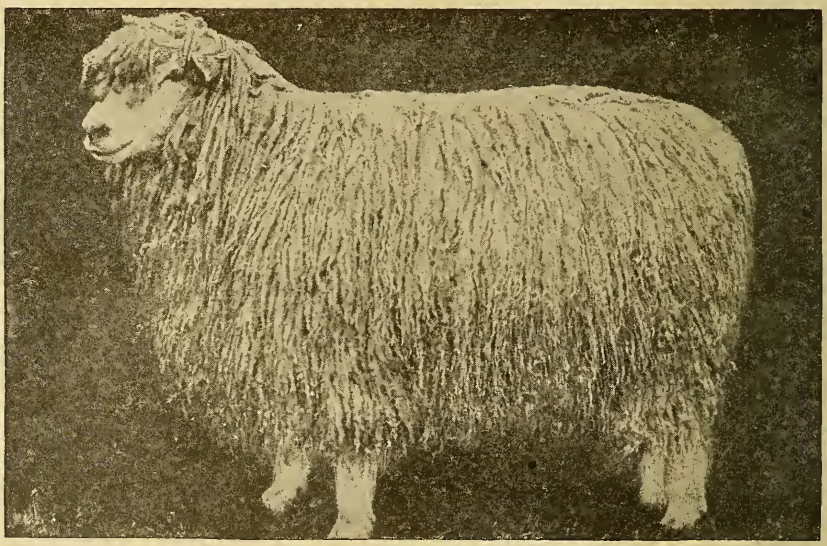


Fig. 1. Cotswold Sheep.

varieties are usually heavy in the carcass, long and heavy in their fleeces, white on the head and legs. Short-wooled sheep, on the other hand, are smaller and lighter in body, yielding a short, fine wool, and are brown or even black on the face and legs.

British Wools. The principal long-wooled breeds of this class are the Cotswold, Lincolns, Romney Marsh, Leicesters and Hamptons.

The short-wooled sheep are well represented by the Sussex and Hampshire Downs, the Shropshires, Dorsets and Exmoors.

The Cheviot sheep may be mentioned as a middle-wooled animal.

Long-wooled Sheep. The Cotswold. The head is surmounted by a tuft or long lock of wool hanging over the eyes, the fleece is heavy, thickly set and characterized by a rather bold and large curl. The fleece under ordinary circumstances will weigh from eight to ten pounds, but in some cases double this weight is not uncommon in good flocks.

Fig. 2. Lincoln Ewe.

Lincoln Sheep. These are considered the largest and heaviest fleeced sheep. The staple of Lincoln sheep fleece is long. The particulars of three fleeces, not unusually large, will be interesting. By measurement the staple of each fleece was $20\frac{1}{2}$ inches long; each individual fibre was strong, and the strength maintained throughout the entire length. These fleeces weighed respectively $18\frac{1}{2}$ pounds, 20 pounds and $20\frac{1}{2}$ pounds. The Lincoln in many respects resembles the Cotswold sheep, but has a less prominent

tuft on the forehead. The wool has a peculiar glistening appearance, which has earned for it the name of lustre wool.

The Romney Marsh form another distinct breed. They are a heavy-carcassed, long-wooled, hornless, white-faced breed.

Leicester Sheep are known also as the Dishley breed. The Leicester is smaller in size than the three previously named; the wool is shorter and less abundant, and the topknot is either wanting or very scant. This breed of sheep has extended all over the world.

Hampton Sheep. The Hampton breed is generally spoken of as a long-wooled, white-faced and hornless breed.

Short-wooled Sheep. Foremost among the short-wooled sheep may be mentioned the Southdown or Sussexdown, native to the chalk range which extends to the east and west of Brighton, England. The Sussexdown sheep is of a very symmetrical appearance, and the beauty of its form is the more apparent on account of the shortness of its fleece. The face and feet are fawn-colored, the crown is well covered with close wool, which comes well forward upon the cheek. The fleece is short and firm as a board, showing cracks down to the skin, where it refuses to bend.

Hampshire Downs are a larger, coarser looking, slightly longer wooled race of sheep, darker faces and legs.

The Shropshire Breed. The general character and symmetry of this sheep is not as uniform as the two last named breeds. The face is almost black, with a firm helmet of wool extending unbroken between the ears on the forehead; few gray hairs are in the wool, and should they appear, will be found near the tail. Shropshire sheep are bred in nearly all parts of the world.

The Oxford Down has many points in common with the Shropshire breed. The chief point of difference is the Roman nose and the topknot, which is composed of a long lock of wool.

The Dorset is white-faced, horned, and has very short wool.

The Cheviot breed is distinct from the common mountain or black-faced breed. The wool is good, though inferior to that of the Southdown, and far surpasses that of the black-faced mountain breed. As the Cheviot race is equally hardy and is capable of sustaining cold, it will not be long before the Cheviot supersedes the mountain sheep of the Cheviot range of hills.

Saxony Wool grown in Germany is the finest in the world. The fibre is fine and rich, and the great number of serrations make it a good felting wool. The very finest of fabrics are made from it.

The Australian Wools are of very fine quality and are generally classed under three heads: Port Philip, Sydney and Adelaide. The first mentioned is the best, Sydney coming next and Adelaide being inferior to the other two.

Fig. 3. Ramboullet Ewe.

The Domestic Wools of the United States consist of practically three divisions:

First.— *Fleeces*, often spoken of as Washed Fleeces. This wool comes from Ohio, Pennsylvania and Michigan. It is about equal in fineness and fulling quality to Australian wool.

Second.— *Bright Wools.* These are coarser in quality and have more lustre. The states which produce them are Missouri, Indiana, Maine, New Hampshire, Vermont and Kentucky. They

are largely used for serges and worsted dress goods. The quality is commonly spoken of as being quarter blood or three-eighths blood, meaning that the animal from which the fleece is sheared is supposed to contain one-fourth or three-eighths Merino blood by interbreeding.

Third.— Territory Wools are about the same in quality as fleeces, and are grown in Idaho, Montana, Arizona, Utah, and one or two other western states. The per cent of shrinkage in these is very great, owing to the particles of soil, etc., clinging to the fleece. It is not uncommon for 100 pounds of "grease" wool to weigh after scouring only 25 or 30 pounds.

Lake and Georgia is another smaller grade of domestic wool grown in Georgia and Louisiana; in quality about equal to *Bright* wools.

South American Wools range from very fine to carpet wool.

Montevideo is fine stock, resembling in this respect Australian.

Crossbreds come next, running from a three-eighth stock suitable for a worsted serge to braid wool.

Braid is a little finer than carpet wool.

Cordova is the coarsest South American wool which finds its way into the United States, and is used by worsted spinners for carpet yarns. It contains about fifteen per cent of three-eighth quality wool.

Alpaca is also a South American wool, but as it is very similar to hair, it is generally classified with mohair. (See page 12.)

Irish and Canadian are lustre wools of medium quality and length, and are generally used for worsted yarns.

French Sheep. There are three great central and western breeds of sheep in France: the Choletaise, having a dark circle around the eyes, a better form than most of the other French species, and having a good fleece; the Berrichome du Crevan, which yields much milk and wool; and the Larzac, a short, thick-set animal, with long fibres, but not very abundant wool.

La Chamois. The fine, silky wool of the pure Manchamp breed, is remarkable for its qualities as a combing wool. This is owing to the strength as well as the length and fineness of the fibre.

Spanish Merino. The breed for which Spain was formerly

celebrated originated in the export of English sheep in exchange for Spanish horses, and their subsequent cross with a native breed. This noted breed may be distinguished from the British sheep by the covering of wool over the forehead and cheeks. The horns are large and ponderous and convoluted laterally. The wool is long, soft, and twisted into silky looking spiral ringlets. The word Merino signifies an overseer of sheep and pasture lands.

Some of the descendants of the Merinos were carried into Germany at the beginning of the present century, and this gave rise to the fine Saxony wools for which Germany is celebrated. This well-known breed is now reared in Australia, and holds the

Fig. 4. American Merino Ram.

first place as to quality, strength, etc. Australia occupies the first rank as a wool-producing country.

Levantine Carpet Wools. The following wools are for carding, and are made into filling for carpets. They are generally washed wools.

China Fillings. The best China filling wools are grown in the northern part of that country. These wools are coarse, short,

and contain kemp or dead fibers. The different grades are spoken of as No. 1 Open, No. 2 Open, and China Ball.

Skin Wools come from Servia, Turkey, and the country around Salonica.

Khorrassan Autumns and *Trans Caspians* are chiefly used for felt, but as they are also used for carpet filling they are mentioned here.

The Combing Wools from the East for carpet warp yarn are as follows:

Washed Syrian is grown in three grades: *first*, Washed Aleppo, a white wool; *second*, Washed Awassi, also white; *third*, Washed Karradi, white fawn or mixed with dark fibers. These are long, strong, deep-grown wools, and spin to about 14^s worsted.

Angora Wool from Angora comes chiefly in the unwashed state, and spins to about 16^s.

Scotch carpet, which really comes under the head of British wools, is a deep-grown, deep-bottom wool. It runs to a hairy top, or is coarser at the end of the fibers than near the animal. The noil would be quite valuable on account of its fineness if it did not contain dark fibers. This wool generally spins to 14^s or 16^s.

Donskoi comes from the southern part of Russia, generally in the washed state, so that the shrinkage is not more than ten or twelve per cent. It is very white, coarse at the top, and has a cotted root. A small part of this clip is adapted to luster purposes, and is sometimes mixed with mohair.

China carpet is kempy, but of good length, spinning to 16^s. The greater part is a carding wool.

White Bokhara and *White Turkistans*, although used sometimes for combing, are generally made into felt for felt boots. They are not really white, but are mixed with dark fibers.

The noil from these combing wools mixed with white goat hair (from England, Germany and France), white cattle hair, and the lower grades of worsted card waste, is manufactured into carpet filling.

The Goat. Opinions of naturalists have been divided respecting the original stock of the domestic goat, but it is generally accepted to be a descendant of the Ibex.

Mohair is produced by the Angora goat. This animal inhabits

the tract of land which surrounds Angora, in Asiatic Turkey, where the goatherds bestow much care on their flocks, frequently combing and washing them. In color it is milk white, the legs are short, horns twisted and spreading. The hair on the whole body is disposed in long, pendulous, spiral ringlets. The fibre composing the fleece, which is called Mohair, has a bright, shining, metallic luster.

Cashmere Goat or Thibet Goat. Cashmere is the name of a country and city in India. The animal of this name will not admit of a particular description. It is subject to many varieties, differing both in color and in quality of hair of which the fleece is

Fig. 5. Angora Goat.

composed. The principal points in the most approved breeds are large ears, limbs slender and clearly formed, horns not spirally twisted, and above all, the long and silky fleece.

The Alpaca is of the Llama tribe, and is found only in the mountain regions of the southern part of Peru. The wool of the Alpaca closely resembles Mohair, and is of various shades of color, black, white, gray and brown. It is pre-eminently distinguishable for its brightness and lustre, its extreme softness and great length of staple.

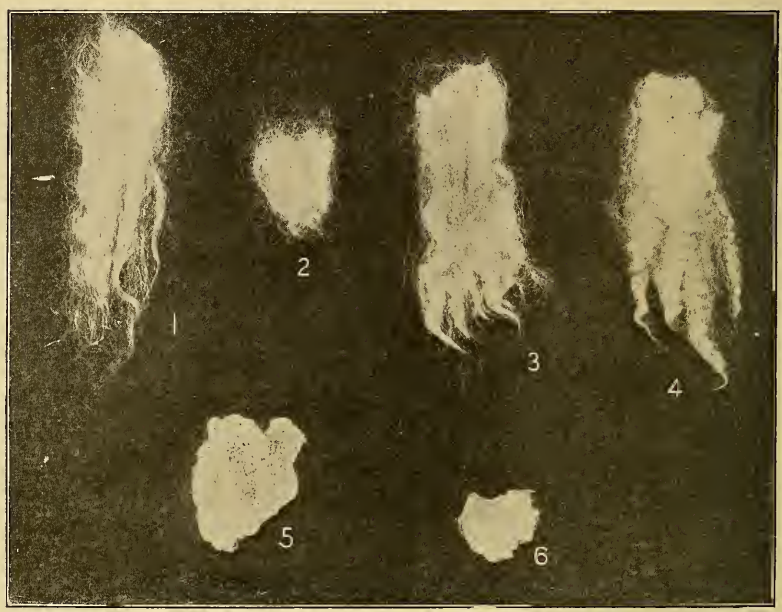
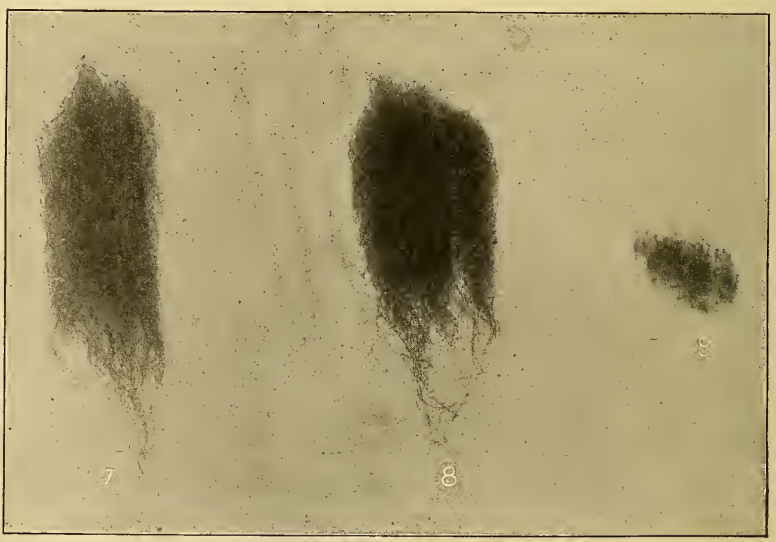


Fig. 6.

No. 1, Mohair. No. 2, Mohair Noil. No. 3, Alpaca. No. 4, Canadian Washed Fleece. No. 5, Fine Scoured Territory. No. 6, Same in grease state.



No. 7, China Camel's-hair. No. 8, Russian Camel's-hair. No. 9, Russian Camel's-hair Noil.

The Guanaco is found in South America. The general color is rich brown, the head and ears being gray.

Camel's-hair is grown mainly in two countries, China and Russia.

China camel's-hair is the better grade, being finer and lighter in color.

Russian camel's-hair is dark and coarse in comparison to the former. These stocks are often sorted into two qualities in the mills, the finest quality growing close to the animal's body, while the longer and coarser hair projects beyond. Camel's-hair is

Fig. 7. Young Angora Billies, grown by W. J. Hughes, Kendall Co., Texas.

generally spun into worsted yarns, the comb-waste or noil being used in the manufacture of woolen dress goods. Much of the long stock is manufactured into press-cloths, used for extracting oil from cotton seed.

WOOL AND HAIR FIBER.

Textile fibers or materials may be arranged in three classes, Animal, Vegetable and Mineral. Each of these classes of fibers possess certain properties, which have their influence on the fabric. Quality, softness, elasticity, strength and lustre are important factors in the manufacture of textile fabrics. Although unnecessary to enter into all the details concerning the different sorts and varieties of wool, a clear idea of what is generally understood

by the terms Clothing and Combing Wools, or short and long wools, must be obtained.

Wool and hair are two very different fibres. Wool is softer than hair; it is wavy and curly, and more flexible and elastic. Hair is generally stiff and straight.

There are several animals whose fleeces contain wool and hair. Among these may be classed the Thibet goat, of Cashmere, the Llama and the Vicugna. When the fibres of the Camel and Angora goat are considered, the resemblance to wool is more pronounced, but the level, stem-like appearance is manifest. The smooth, flat surface of hair is also very perceptible. With wool, on the contrary, the surface of a fibre is rough and serrated. When examined under a microscope the surface appears like the edge of a saw, or as the tiles of a roof overlapping each other at the edges. (See Fig. 8.)

Wool may be described as a cylinder, whose surface is covered with scales, notches, serrations or imbrications of irregular sizes overlapping each other, and tapering from the root to the tip of the fiber. It does not grow independently, as hair, but in locks. A lock of wool is a number of fibres which grow in one mass; this is said to be due to the curly nature of the fiber. When such a lock is drawn between the thumb and finger-tips to the root, those imbrications, or sawlike teeth, are more or less perceptible to the sensitive touch of an experienced and skillful wool sorter.

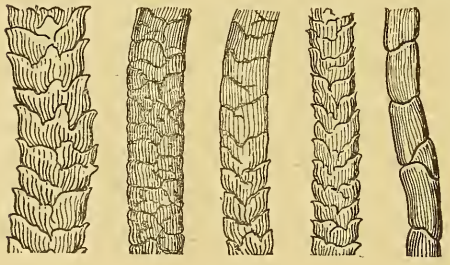


Fig. 8.

No. 1, Medium grade wool fiber. No. 2, Camel's-hair. No. 3, Kemp, or diseased fiber. No. 4, Merino. No. 5, Mohair.

In the manufacture of woolen cloth, the wool that has the most serrations is considered the most valuable. It is by virtue of this characteristic that the matting or felting property is given to the wool, and these serrations or scales should therefore be preserved in all the after-processes of manufacture.

The purpose of carding wool for a woolen thread is to intermix the fibres in all possible ways. The fibres of a woolen thread

are not laid parallel to each other, but are crossed and intermixed, so that the thread resembles the hairy body of a caterpillar more than anything else. The points of the scales projecting out all over the body of the thread, and the fibres interlocking each other in one entangled mass, hold firmly and closely together.

There is another quality in these minute scales which is not generally noticed: the under side of each scale is rough; this roughness offers resistance to the interlocking of the scales or serrations. The consequent results which are obtained by reason of this property are valuable. By adding a lubricating fluid like soap and water, the fulling, milling and felting process is accomplished by means of great pressure upon the fabric, and the friction caused by the cloth passing through the rollers or under the weight of heavy hammers, generates heat, so that felting takes place. The structure of the fibre, moisture, friction, pressure and heat play important parts in this.

Wool fibre is covered with an endless number of dried-up cells, which are composed of a soft, gelatinous membrane, so that when moisture and heat are applied, these cells become soft. When pressure is brought to bear upon them, the fibres are literally pressed into each other, the downy, fur-like teeth and scales hook into the serrations of other fibres whenever forced into contact, and become inextricably interlocked. This causes the fibres to decrease in length and increase in thickness and bulk, therefore getting heavier in proportion to their length. This fact must always be borne in mind when analyzing samples of woolen cloth.

This interlocking, or felting, is determined by the quality of wool and the number or fineness of the serrations in the fibre. If there are no such serrations, there will be little fulling properties.

Wool possesses another peculiarity: it is longitudinally waved. This waviness of the fibre has much to do with its felting nature, and assists in interlocking and squeezing the serrations of one fibre into those of another, as one would interlock the fingers when clasping hands. So remarkable is this property that with many kinds of wool it is only necessary to mingle the fibres, wet them and beat gently, to get them to combine and form a fabric.

The fibres of Merino, Saxony or fine Australian wools measure from .012 to .018 of a millimeter in diameter; these wools average .013 millimeters, or equal to 1,954 fibres to an inch, if laid side by side.

The average Saxony fleece weighs $1\frac{1}{2}$ pounds scoured. Saxony wool may be accepted as one of the finest, softest and best wools grown. In a single fibre of Saxony wool there are from 2,700 to 2,800 serrations in one inch, therefore this wool has superior milling and felting properties.

The fibre of Merino fleece has in one inch 2,400 serrations, and is another exceptionally good felting wool. Southdown wool has 2,080 serrations to the inch, while Leicester wool has only 1,860. The latter wool has somewhat inferior felting properties, for in general it may be said that the most valuable wool possesses the greatest number of serrations in a given space, and that it is in such wools that the felting properties are highest. This is in general true, but there are some exceptions. For instance, Cape wool, although having fine curly fibres in the fleece and a large number of imbrications, is not classed as a first-class felting wool. If examined under a microscope, it apparently possesses all the outward characteristics of an excellent fulling wool; but in practice it is only of a secondary character. Buenos Ayres and Port Philip wools, when compared as to their mechanical structure, are very similar; both have a fibre fully imbricated, but their fulling or felting powers are as opposite as it is possible for the fleeces of the same genus of animals to be. Port Philip is considered one of the very best felting wools, while the inferiority of Buenos Ayres is universally acknowledged.

These delicate fur-like imbrications, and also the fact that the central portion of the fibre is a narrow and irregular canal, are the true foundations of wool being one of the easiest fibres to dye, these peculiarities making it one of the best absorbents of color. It is to preserve these infinitesimal serrations that oil is applied to wool before undergoing the carding process. These serrations should of course be preserved in all after-processes, because, as already stated, in the finishing department the felting process, "which is the very strength of a fabric," is accomplished by means of these imbrications.

In practice the wool sorter and manufacturer judge wool by its softness, whiteness, or color, curl and waviness, elasticity of staple and length, and a disposition to felt. It is needless to state that such a delicate structure should be handled with extreme care and skill.

Softness varies greatly, according to the quality and description of wool, but whatever the breed or kind, it must possess a soft and warm feel.

All wools are not white, for some sheep have a mixture of white and black. Then the climate and soil have their effect upon the wool, giving fibers of black, brown-gray and red-brown. These colors are found mostly in Egyptian, East Indian and Spanish sheep. These wools are generally used in their natural shades, or dyed into darker colors, either in piece-dyed goods or in the wool for mixtures.

White wools used in the manufacture of fine flannels and opera cloaking are sometimes bleached to make them still whiter, therefore a pure white wool is most valuable.

The quality of wool depends to some extent upon the curl and waviness; as a rule the coarser fibres have less crimps or waves than the finer wools, yet it is not always wise to take this as an absolute guide. The wavy or crimpy nature of wool has much to do with the elasticity of the fibre. As an example of the meaning of elasticity, take a handful of raw cotton and compress it firmly. The cotton will not resist the pressure and will retain its position for some time afterwards, but wool after pressure will return to its former shape. It has a soft, full and lofty handle during the pressure, and when the wool is released it flies back as though it were a sponge. The length of the staple is of great importance. By staple is meant a group or lock of fibres. These will vary from any definable length to twenty inches long; the long wools are usually coarser and stronger than short wools, but all long wools are not necessarily coarse, nor all short wools fine.

Kempy wool. This is dead hair found in the fleece of sheep that have not had proper care and attention. Kemps, as these dead fibres are called, in White Highland sheep are about two inches in length, while in finer bred sheep they are short. Kemp is a white, shining hair, which will not take a dye of the same

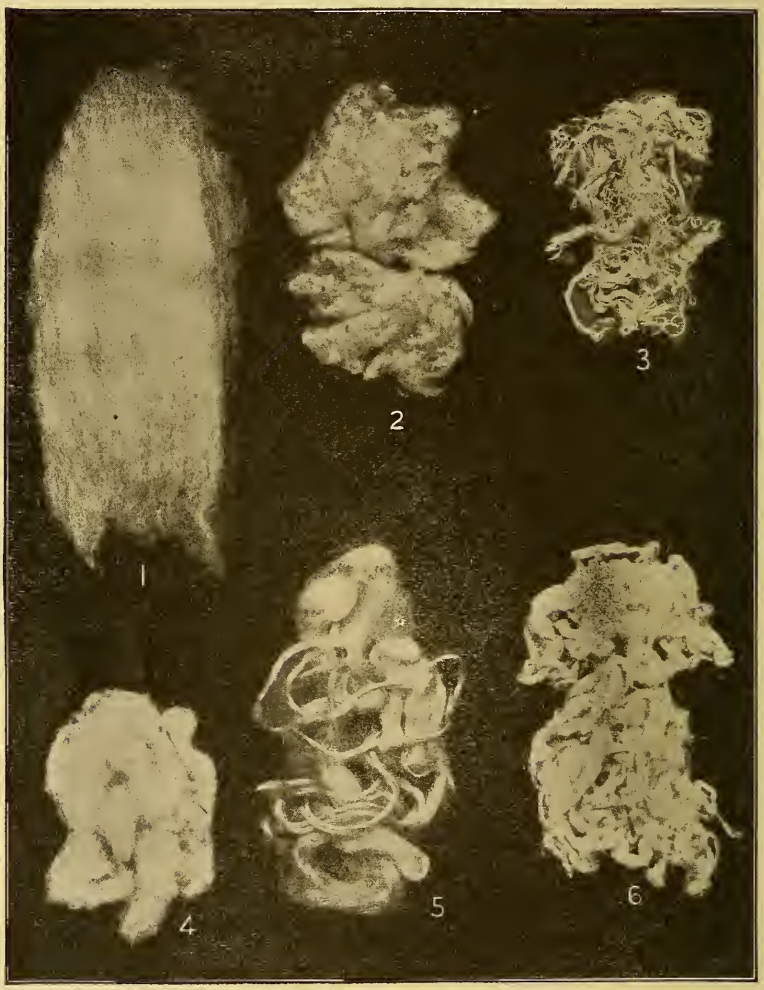
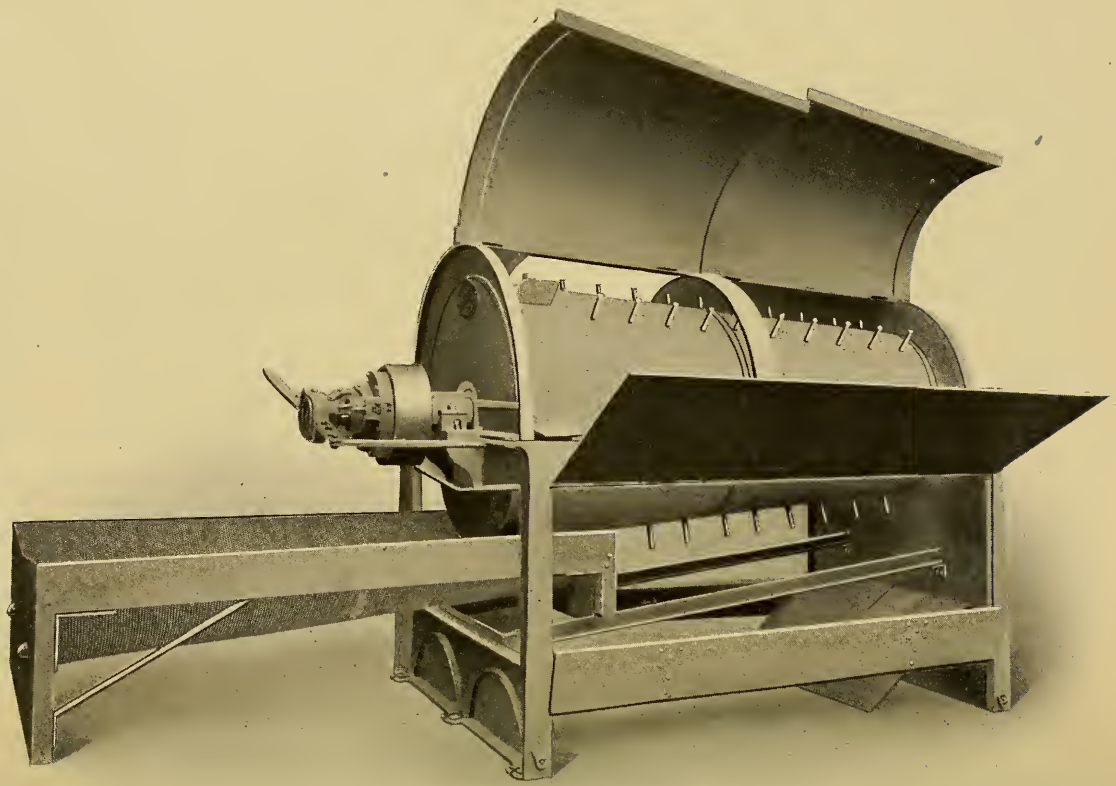


Fig. 9.

No. 1, Quarter blood top from South American crossbreds. No. 2, Quarter blood noil from same. No, 3, Hardends from quarter blood stock. No. 4, Garnetted stock from Australian threads. No. 5, Lap waste. No. 6, Carbonized card waste.



CONE DUSTER FOR WOOL, WASTE, ETC.
The James Hunter Machine Co.

shade as the other fibers. They never change in the process of carding and spinning and will not unite with the other wool fibres, but lie on the surface, held down by other fibres.

First clip. The finest and shortest wools are generally lambs' wool. The animal is at this time from six months to one year old and is called a hog or hogget.

Second clips are stronger and longer. Wool of the second clip is from yearlings, while the subsequent growths are designated fleece wools and wether wools.

Wools that will spin to extra fine counts are Silesian, Saxony, Port Philip and Sydney.

Wool that is obtained by the pulling process from sheep that are slaughtered for food, is called skin wool, pulled wool, or sometimes dead wool.

Difference between Wool and Fur. Wool, fur and hair are all the coverings of different mammiferous animals. The term wool is applied only to that fibre which grows on sheep similarly to the hair or fur on other animals, but the wool fibre is distinguished by its scale-like outer surface and its felting and spinning properties. Hair, as distinguished from wool has no scaly structure, with few exceptions, being a smooth, straight filament, having no felting properties and spinning with great difficulty. Fur is the undergrowth which is found on most hair-bearing animals, and has to a modified extent the imbricated structure and felting properties of wool. For textile purposes the best classifications are probably as follows: Wool, that fibre grown on sheep which has both felting and spinning properties. Fur, that class of fibres which has felting properties only. Hair, that fibre which with the few exceptions can be neither spun nor felted.

Bristles, hedge-hog spines and porcupine quills are all modifications of hair, having the same composition, mode of formation and general structure.

Of cow hair, horse hair, dog hair, human hair, the last-named is softest and most wavy, though very different from wool.

WOOL SUBSTITUTES.

Wool Wastes. *Noil* consists of the short fibre which is combed from carded wool intended to be manufactured into worsted

yarn. It is a valuable stock, and is used in woolen goods. It is made in many grades, and is generally mixed with other fibre in manufacturing. Many desired effects in cloth are obtained by the use of wool, mohair, or camel's-hair noils only.

Ring Waste, Yarn Waste and Hardends are waste threads in process of manufacture, and come from the drawing-room, spinning-room, etc. They are garnetted before using. In other words, these stocks are run through the garnett machine to convert them from the form of thread into loose fibres.

Card Waste, as its name implies, comes from the carding machines, and is used in woolens of a medium or low grade.

Flocks are very short fibres, generally gigged, fulled, or sheared from cloth in the finishing-room. They are used largely in the manufacture of low-grade goods.

So much misunderstanding exists concerning shoddies, that it has been deemed advisable to have the student know what the English authority, McLaren, remarks upon the subject: "A few words must here be said on remanufactured fibres, known to the world under the common name of 'shoddy.' There are few more unreasonable and foolish prejudices than that against shoddy, and so far from it being a term of reproach, it should really be one of praise; for the man who first brought shoddy into use has conferred an incalculable benefit on the world, and enabled millions of persons to be warmly and cheaply clothed, who must otherwise be shivering with cold. It would be as unreasonable to despise paper-makers because they use up linen rags, or to despise dyers who use up colors made from coal tar, as to despise manufacturers who use up waste woolen rags as shoddy. It is said that 125,000,000 pounds of shoddy, mungo, etc., are manufactured into cloth every year in England alone. If this immense quantity were wasted, it is difficult to estimate the increase which would take place in the price of wool and the consequent dearness of cloth, but the result would be that countless persons would be unable to afford proper clothing."

Shoddy is manufactured from soft rags, such as woolen stockings, flannels, blankets, woolen comforters, or any soft, woolen goods. The rags from which they are made are generally catalogued "Soft Woolen Rags."

It will be noticed that when these soft rags are pulled apart by the ragpicker that the product must necessarily be only of medium length. When examined under a very powerful microscope shoddy is seen to contain mixed fibres, coarse and fine, white and colored. It is impossible for the shoddy fibre to show the uniform and regular structure of the original wool fibre, as the scales and serrations are more or less destroyed in the first manufacture, so that the fibres lose their elasticity and felting qualities. The nature of the fabrics from which shoddies are made do not as a rule require very good felting wools. Shoddy was first introduced to the public in 1813 by Benjamin Law of Batley, England.

Mungo. The invention of this much-abused article of commerce is due to George Parr of Howley Mill, near Batley, England. The name is derived from the curious vernacular of the district, translated,— mun, must; go, go: must go,— mungo. It is said to have originated in an argument concerning a very poor grade of stock which could scarcely be put in operation. One man said it would not go, when Samuel Parr, brother of George, remarked: "It mun go" (It must go).

Mungo (an English term) is manufactured from such materials as broadcloths, overcoatings and felted woolens, and are designated among the rag dealers and buyers as "hard woolens." There are two varieties of mungo, "new" and "old." The former is made from new rags, collected from tailors and wholesale clothing manufacturers, while the latter is made from old rags. As hard-made woolens have had a great amount of felting, it is difficult to get any great length of fibre; but it has one great quality in its favor, that is its fine felting property. It is this felting together of the fibres that makes it difficult to get any great length of staple from the ragpicker.

Extract. This material was invented also in Batley, England, about the year 1854. Extract is derived from waste fabrics that have a cotton warp and woolen or mohair filling, or in fabrics where the cotton has been mixed with the raw materials. The word extract gives some idea of the substance or material. The rags are subjected to a chemical treatment, the object of which is to recover the animal fibres. The vegetable thread or cotton mixture is destroyed by a process of carbonization. The funda-

mental principle of the process consists in the rags being steeped in a solution of sulphuric acid and water, and then heated to 140° C. The water is evaporated, leaving the sulphuric acid in a concentrated form upon the tissue; in which state it has a very powerful action upon the vegetable matter (cotton) which may be contained in the rags, and thus reducing the vegetable matter to such a condition that it powders when put through the carbonizing duster. The powder or dust is taken away by means of a fan. The recovered woolen fiber is now taken to the washing

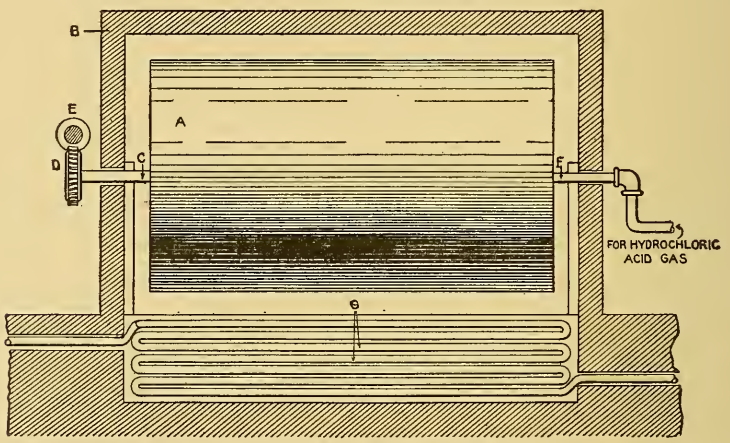


Fig. 10. Apparatus for Dry Carbonizing.

machine to remove the acid. The two processes used in carbonizing or extracting, as it is commonly called, are:

1. Carbonization of the vegetable substances with liquid acids and salts.
2. Carbonization by the application of gases.

The former may be divided into four operations.

The immersion of the wool or cloth into the diluted acid liquor of 5° to 7° Baumé; partial drying in a hydro-extractor; exposure to a temperature of from 200° to 300° Fahrenheit, and the removal of the acid for the application of dyes. The manner of carrying this process out will be fully described under wool carbonization.

Dry Carbonization is the introduction of hydrochloric-acid gas to the wool. The wool is placed in an air-tight chamber,

where it is exposed to the action of the gas for several hours. The gas is then stopped, and steam enters the pipes, raising the temperature to 215°. All the apertures are opened after a short time, and air is introduced to remove the fumes of the gas. The wool is then washed, as before indicated.

Fig. 10 shows a practical machine for this method of carbonizing. A is a steel cylinder, into which the rags or other stock is introduced. This cylinder is inside the brick house B, and revolves on the shaft C by means of the gear D and worm E. F is a steel pipe, through which the gas enters the cylinder, and also acts as a shaft, as does C. The hydrochloric-acid gas is made in a retort from a mixture of salt and sulphuric acid. The retort is found to contain crude glauber salts when the process of carbonization is completed. In order to heat the house B, and consequently the contents of the cylinder, a furnace whose flue coils under the floor at G, is sometimes used instead of steam.

This method of carbonization is but little used in this country, and then only on dark stocks, as the process has a tendency to impart a yellow tinge to white wools.

The felting properties of extracts are not good. They are wanting in fullness, elasticity and the lofty, springy character which is so noticeable in new wool. These characteristics are of course necessary for the production of the best cloth.

Extracts can be obtained in many shades and colors suitable for almost any class of fabrics. The wet-extracting process has extended to new wool, for the purpose of freeing it of burrs, straw, seeds and other vegetable substances. The process has been so much perfected that it is taking the place of the burr picker, which was formerly the only means of cleaning wool. This fact is so evident that there is every reason to believe that eventually the chemical will supplant the mechanical separation of vegetable substances from the raw wool, save those stocks which contain large burrs.

WOOL SORTING.

It is a natural supposition that the manufacturer sorts the fleece of wool into the divisions, varieties and qualities which best suit the requirements of the fabric upon which he is working.

The wool sorter requires very few tools or implements, the appliances most necessary being a sorting table with a wire screen top, whereon to lay the fleece, and through which any loose dirt, straw and other impurities may fall, a pair of wool-sorter's shears for cutting off the paint and tarry matter, and as many baskets or slat boxes as there are qualities and kinds to be made.

The accompanying picture (Fig. 11) shows two wool-sorters' benches and general arrangement in use in some large mills in this country. A is the screen on the table, through which some of the impurities fall. The boxes or crates for the different sorts are placed in two rows at right angles to the bench, and forming an alley to the rack B, on which the bags of wool are placed.

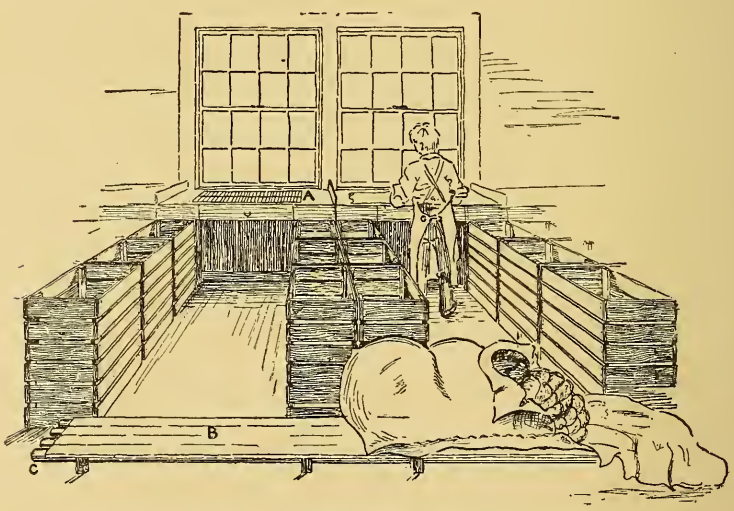


Fig. 11. Wool Sorters Bench.

Under these racks at C are the steam pipes, which heat the wool so that the fleeces can be opened out easily. In cold weather the yolk, or natural grease, in the wool becomes so stiff that unless heat is applied the fleeces cannot be spread out flat on the bench without tearing them apart.

To divide the fleece into the different qualities, or sorts, that are usually understood to be the standard kinds, the nature of the fleece must be thoroughly understood. Wool is taken from sheep, young and old, male and female, when shearing, and the

fleeces must be graded according to age and sex. A lamb or sheep before the first shearing is called a hog or hogget, and at this period may be anywhere between six months and a year old. A sheep after the first shearing is called a wether, the age may be one year or more.

The wool of the first clip or shearing is pointed at the, tip and a lock or staple of wool dwindles to a point, these characteristics distinguishing it as lambs' wool or hog wool. Hog wool is more valuable than any later shearing, which is known as wether wool, because the natural formation has not been interfered with, and therefore the wool can be spun to finer counts. The fibre lock, or staple, of wool from the wether is, on account of the shearing, more or less square at the tip, but the fleece is generally more free from small pieces of twigs, straw, dirt, and other vegetable impurities which are usually found in the lamb's fleece. On account of these differences in the value of these two fleeces, it is essential that the sorter be able to judge which is hog and which is wether fleece.

There is another method of judging the two fleeces, and that is by pulling a staple of wool from each fleece. If the wool is from a wether, the staple will leave the skin and come away from the other wool more freely without interfering with the fibers at the root; but if it is a hog's wool, when the staple is pulled away some of the fibres of the surrounding staples, or locks, will adhere to the staple drawn out. Thus hog wool does not leave the fleece easily and cleanly, but the staple of the wether will come away without any fibres adhering to the roots of the wool.

The fleece of a sheep after being sheared, and before sorting, resembles the form or shape of the sheep. The cut on page 27 will give an idea of the various qualities, or sorts, that can be taken from an individual fleece. It must be thoroughly understood that wool from every variety and breed of sheep varies according to whether the fleece is from a coarse or fine breed, whether it is a cheviot or merino sheep, and that each individual fleece contains many qualities of wool. These qualities of the wool in some cases are very low, while in others the qualities are very high. At the same time the variations on the same fleece may differ as much as does the wool from two distinct varieties of sheep. Fig. 12 shows fourteen distinct divisions, or qualities,

of wool on the same fleece. These various qualities are separated by tearing away each division by hand. The fleece is first laid on the sorting table, and the poorest part and the dirty edges torn off. The process is known as "skirting" the fleece. The fleece is then divided into two other portions through the middle, from fore and hind part. The fine part near the ear is then removed. Superfine wool, which is obtained from this portion, is divided into two qualities. After this the shoulder is stripped, which is semifine, and the flank, which gives medium wool. The wool of the upper thigh is classed as coarse, while that of the lower thigh is classed as very coarse. Other qualities are formed by separating wool mixed with straw and tarry matter. As there are so many ways of dividing the fleece, several good divisions are shown here.

High qualities, wools from the best portions of the fleece:

1. Superfine, from near the ear.
2. Fine, between ear and shoulder.
3. Semifine, from the shoulder.
4. Medium, from the flanks.
5. Coarse, from the upper thigh.
6. Very coarse, from the lower thigh.

Low qualities:

1st quality, embracing the lower belly and forehead.

2nd quality, the lowest part of the thighs.

3rd quality, breech locks.

4th quality, tarry and paint marks.

McLaren's description,— different qualities of wool (Fig. 12.):

"No. 1 is the shoulder, where the wool is long and fine. It grows the closest and is most even.

"No. 2 is rather stronger, but otherwise equally good. The best and soundest wool grows on these parts.

"No. 3, on the neck, is shorter than No. 1, but even finer; where sheep are likely to have gray wool it is sure to be found here, and also on No. 4, which with No. 5 grows wool of inferior staple and faulty character.

"No. 6, which covers the loin and back, is coarser and shorter, while on

"No. 7, the wool is long, strong, and hangs in large staples.

On crossbred sheep this part becomes very coarse, and is much the same as

"No. 8, which is the coarsest part of the wool, and is known as breech or britch, and even, when very strong, as 'cow-tail.' When like this it almost resembles horsehair, though it is more brittle and not so smooth and bright.

"No. 9 is also strong, and much the same as No. 7.

"No. 10 is short, dirty and increases in fineness as the front legs are approached; it is known as 'brokes.'

"No. 11 is also short and fine, while

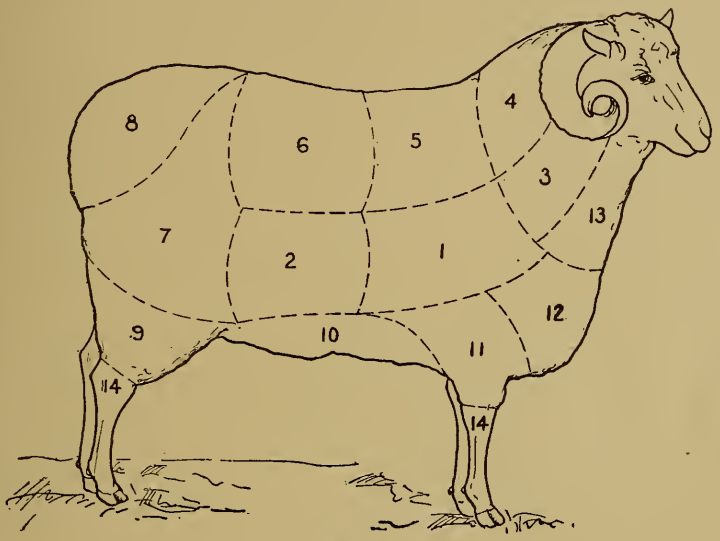


Fig. 12.

"No. 12, the front of the throat, is short and worn with rubbing.

"Kemps, or dead hairs are mostly found in No. 12 and No. 8, though in the latter they are much longer and stronger than in the former.

"No. 13 is the head, on which the wool is very short indeed, rough and coarse like the legs.

"No. 14 it is still worse, and of very little value."

Dr. Bowman's system of dividing the fleece:

"The finest and most even-grown wool is always found on the

two shoulders, about the positions marked A A, Fig. 13; in some fleeces this quality extends more into E and B B and F than in others, and the quality of the wool at B B is not very much inferior, although rather stronger and coarser. These two qualities are called in the woolen trade picklock and prime, or choice, while the wool found in the position C is frequently finer in the staple, but shorter than A A or B B, and likely to be more defaced by irregular or colored hairs; when free from these defects it forms a super quality. The qualities D and E shade into those on each side of them, and as

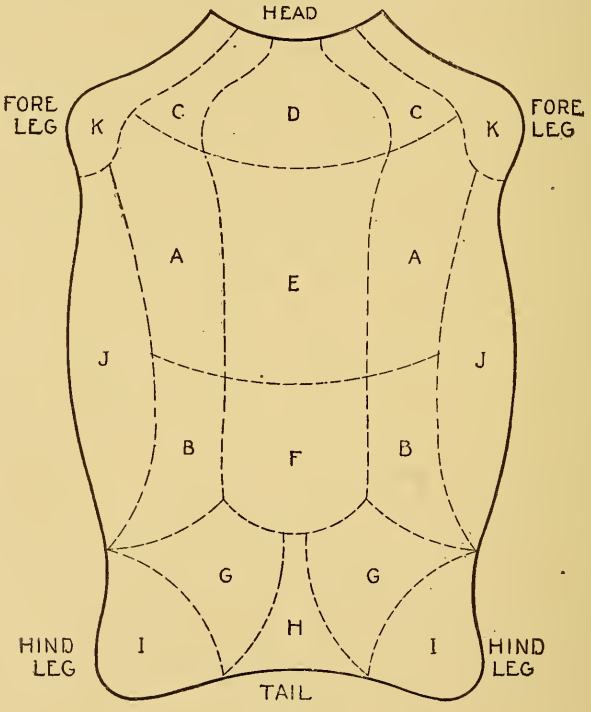
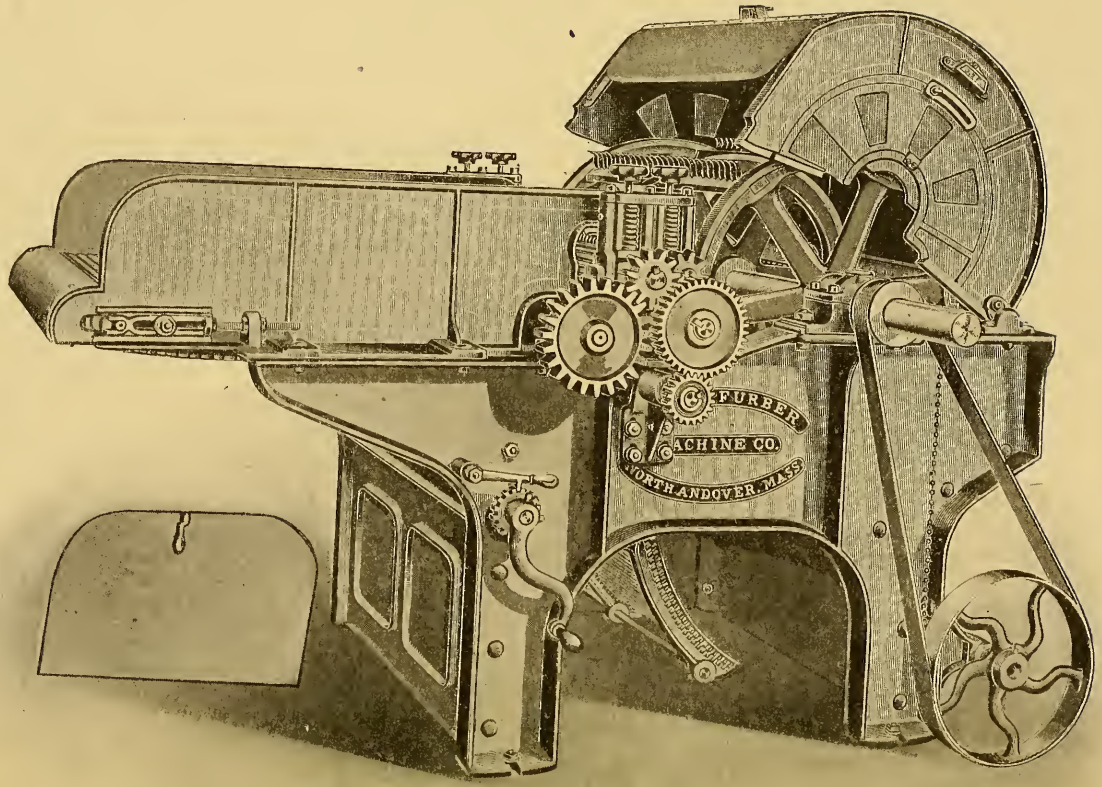


Fig. 13.

they form the apex of the neck and shoulders, they are less deep grown or close in the staple than A or C. The quality F closely resembles B B, into which it shades; and for many purposes, especially for spinning down, A, B, E, and F are frequently used as one quality. In Bradford the wool from the shoulders and neck is usually called blue or fine matching, according as the quality of



MIXING PICKER, WITH FOUR FEED ROLLS—3 FLUTED AND 1 PIN

Davis & Furber Machine Co.

the fleece may be. In an ordinary Leicester fleece it would be blue matching, and would spin to 40s. If, however, the fleece was of a superior quality, such as fine Kent, selected for quality, it would make fine matching, and would spin to 42s or even 44s. If, however, the fleece was a strong Lincoln or Gloucester, it would probably only be classed as neat matching, and would in that case spin no farther than 36s. When we pass beyond F backwards on to the flanks of the sheep the wool becomes long and coarse, the best being found in the positions marked C C; and this would make what is called brown matching or drawing, which would not spin higher than 32s, even in fine, selected fleeces of English wool, and in many not as high. At H and I I the coarsest part of the fleece is reached, where the wool grows in large locks with long, coarse hairs. The latter is called the breech or britch, and can only be used for very coarse yarns and low numbers, not spinning higher than 26s, even when the fleece is comparatively fine in the other parts; sometimes it is also called "say cast." From the extremities of I I there is often taken a lower quality still, which is called tail, or even cow-tail, from the resemblance which the hair possesses to the strong tuft growing at the end of the cow's tail; and of course this can only be used for the lowest numbers. There are usually also a quantity of hard lumps, consisting of matted fibre and dirt, which have to be cut off with the shears by the sorter, and are called toppings; these are smaller in proportion as the flock is well tended and the seasons fine.

In the ordinary English fleeces all these qualities are long enough to be combed, but just around the edges of the fleece, in the position marked J J and K K, and at the furthest ends of D and C C, nearest the head, we have a very short stapled wool, which grows in small tufts or staples, called shorts or brokes, and which are used for carding. In quality they correspond to the longer wools, with which they are associated in the different positions on the body. They are usually divided into three qualities, which correspond to the blue or fine matching; the neat matching and the britch, the finest which are derived from the extremities of D, C C and the position K, are often called super or downrights; those which grow on the position J J, especially the forward part, are called middle or seconds, and those from the

extremities of J J nearest to I are called common or abb; when the fleece is crossbred, and even in some cases where it is not, there is always a tendency to the production of kemps along the skirt, but especially at the parts marked K K and the extremity nearest the head; the kemps occur in the combing wool most frequently in the region of the tail in the part marked H."

None but a skilled workman can sort wools with precision and accuracy; the practiced eye and hand of the wool sorter follows the divisions to its boundary according to the number of qualities required. At one time the manufacturer may require

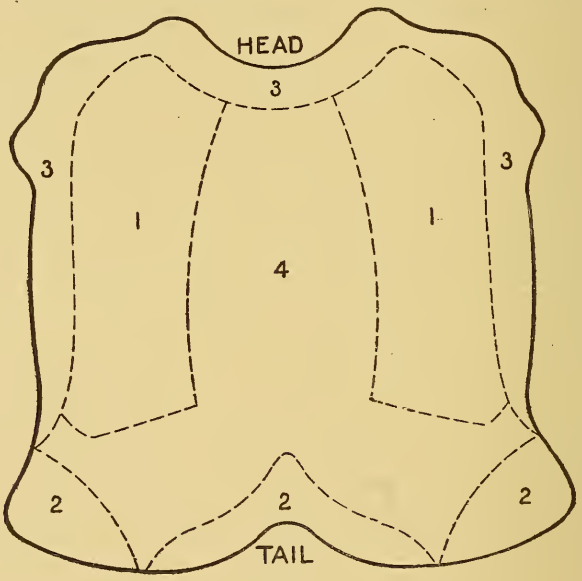


Fig. 14.

his wool fleeces sorted into six or more qualities, at another time he may only require two kinds, with the coarsest breech thrown by itself.

In American mills fleeces are frequently sorted as shown in Fig. 14.

The skirts at 3–3–3 are first removed, and make one sort; then 1–1 are taken for the best quality; after which the strong, coarse locks 2–2–2 are removed for the lowest sort, and the remainder 4 forms still another sort, comprising the good, medium-grade wool.

WOOL CLEANSING.

Arrangement of Dusting, Scouring, Carbonizing and Drying Machinery. The tendency toward continuous automatic processes of manufacture is more marked to-day than at any time in the history of the woolen industry, and owing to the general movement in this direction, we are enabled to secure greater production. In well-equipped mills, especially those running on wools which contain more or less earthy matter, after the fleeces have been sorted and before they are sent to the scouring machines, it is customary to run them through a machine known as the Duster, in order to shake out as much dirt, shives, straws and other extraneous matter as possible, thus making a distinct saving in the scouring process.

Fig. 15 shows the ground plan and sectional elevation of a train of machines for dusting, scouring and drying wool. A is the first automatic feed in which the wool is placed after being sorted. This feed delivers the stock into the duster B, from which it is dropped onto the feed apron C, of the first scouring bowl. This feed apron delivers the wool directly into the first bowl, through which it passes to the second and then to the third. From this point, the wool falls upon a traveling apron D, which delivers it to the automatic feed E, and from which it is carried into the dryer F.

There are a variety of arrangements for this train of machines, wholly depending upon the general plan of the mill. Fig. 16 shows the machines for the operation of this process upon two different floors. It is quite customary where the scouring room is situated on the floor below the wool shop to have the automatic feed and the duster on the floor with the wool shop itself. The wool is dropped upon the floor back of the duster after passing through it, and near which place is a chute through which the attendant occasionally pushes the accumulated stock. This chute leads directly into the automatic feed of the scouring train which delivers the wool into the first bowl. In many plants the dryer is in a different part of the mill from where the scouring machines are situated, and the best method of handling the stock in this case, is to connect the doffer apron of the last bowl with the dryer by means of a blower and suitable pipe.

The apron D, in Fig. 15, may be dispensed with if the dryer and the feed, E, are at right angles to the third bowl, when the

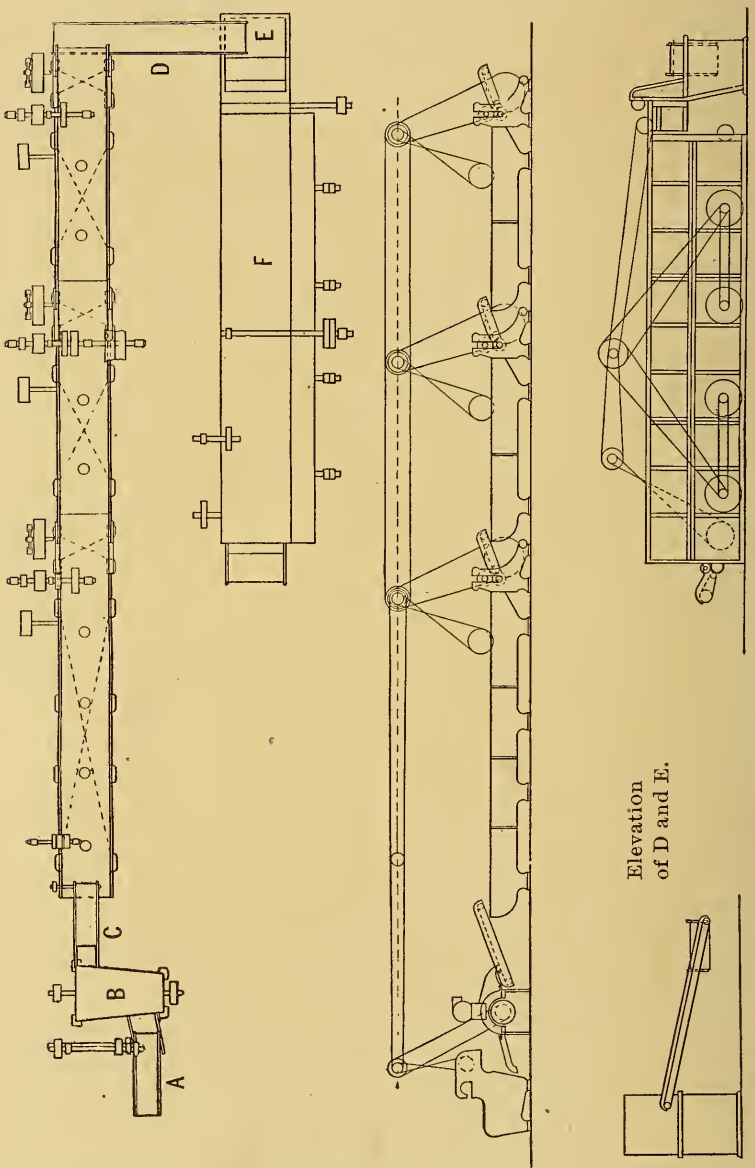
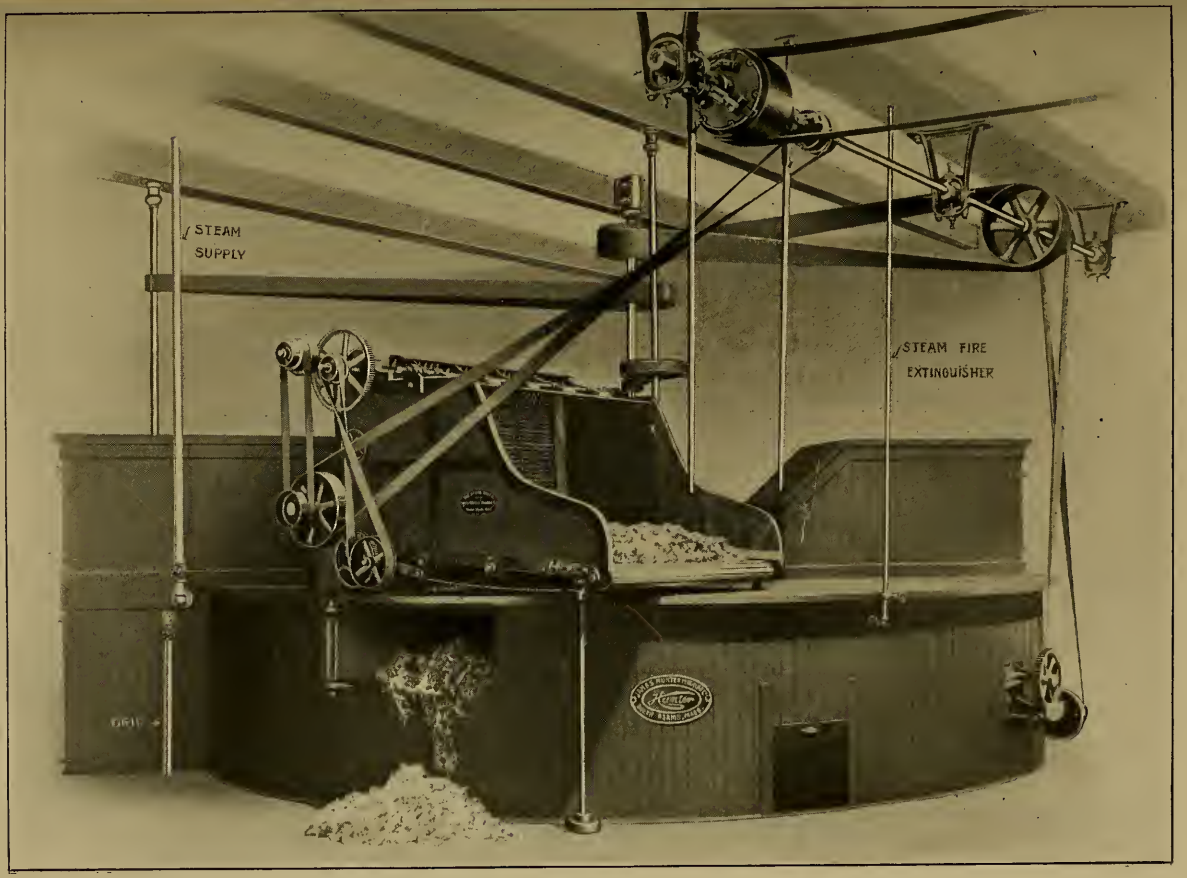


Fig. 15. Plan and Elevation of Scouring and Drying Train. The Lower View is on Two Levels.

apron in the third bowl may deliver directly into the feed. This arrangement also applies if all of these machines are set tandem to one another, that is, in a straight line.



THE STONE DRYER FOR DRYING WOOL, COTTON, RAGS, ETC.

The James Hunter Machine Co.

Carbonizing Train. In mills where burry wools are used extensively, and where carbonizing is largely employed, an arrangement similar to Fig. 17, or a modification thereof, is customary in the better equipped plants. It will be understood that the duster and scouring machines are set in the same manner as in Fig. 15. The apron and feed deliver the wool to the carbonizing bowl, F. From the carbonizing bowl the wool passes directly to the press rolls of this bowl and from the apron attached thereto, is dropped into the feed G, which delivers it to the carbonizing dryer. From this dryer, by means of the doffer apron, it is delivered into an automatic feed of the same width as the crush rolls. The crush roll machine now passes the crushed product to another feed, which delivers it to the duster. In some plants the carbonizing duster J, equipped with crush rolls is employed, but inasmuch as the rolls on this machine cannot be made as wide as those upon the crush roll machine, the former method is preferable.

The wool is now ready for the mixing picker or the dye house, provided acid colors are to be used. If not, another feed may pass the stock into the neutralizing bowl or bowls as in this elevation K and K′, and from there to the dryer or to the dye house. Owing to the variety of stocks handled by woolen mills, arrangements of this nature would be applicable to probably a small percent of the plants, but as many changes and modifications may be made in these arrangements, it is very necessary that some idea of the more advanced methods should be given. Certain combinations of cleansing and drying machinery used in connection with aprons, automatic feeds and blowers could be used with a considerable saving of time and attendance in almost every woolen and worsted yarn mill.

The train in Fig. 17 is especially adapted for scouring and carbonizing noils. The arrangement of the machines is somewhat similar to that of the machines in Fig. 15. Dusting before scouring has been dispensed with, and the scouring machines have been reduced in size and number.

Automatic Feeds. In handling wool and other fibres in the subsequent processes of woolen and worsted spinning, as already seen, automatic feeding devices are used at various points ; con-

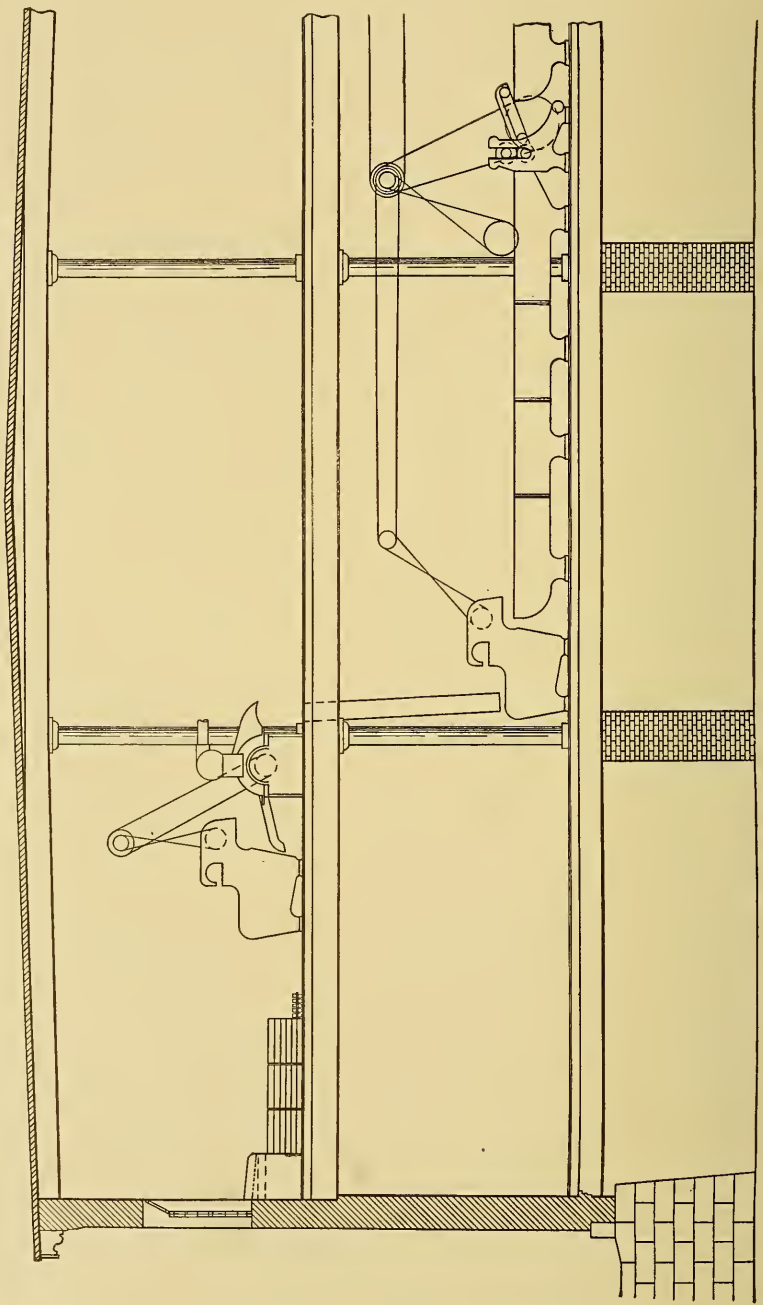


Fig. 16. Sectional View of Train on Two Floors. Duster in Wool Shop.

sequently, a description of the types in general use will suffice until the operation of carding is described, when the weighing

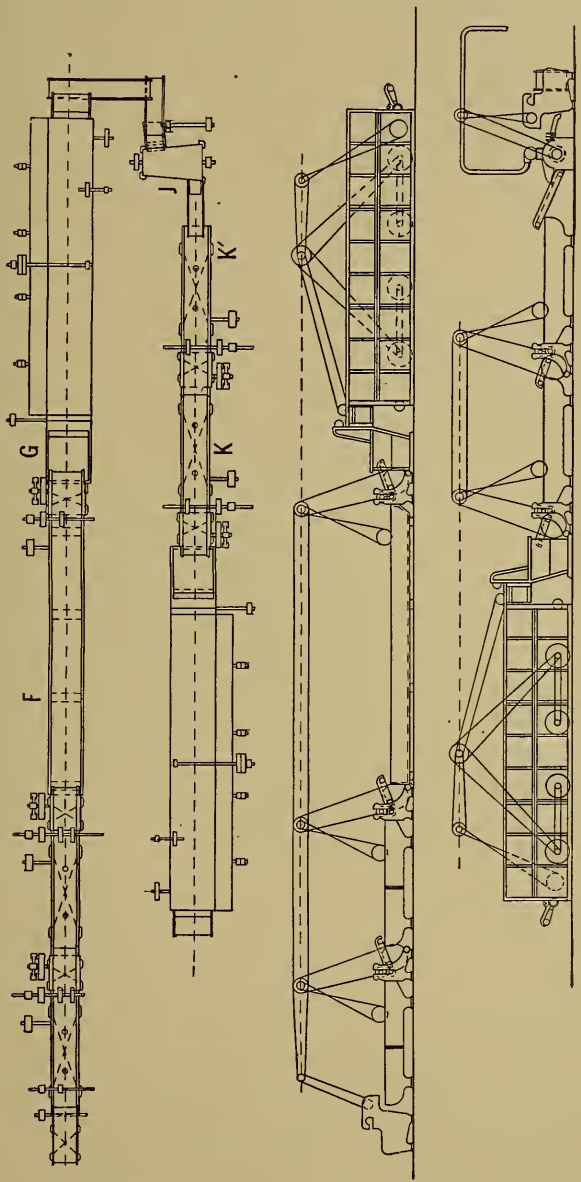


Fig. 17. Scouring, Carbonizing, Neutralizing and Drying Train.

feed will be explained.

The High Feed used ordinarily for grease wools in connec-

tion with the wool duster or washer is built to handle long stock, i. e., from 5″ staple upwards, and is generally used on worsted wools. An elevation of this machine is shown in Fig. 18. Its main features are a hopper, the bottom of which is an endless slat apron, and a spike elevating apron which conveys the wool to the machine which it is feeding. The bottom apron is composed of wooden slats securely riveted to leather apron belts running over suitable apron pulleys as shown at A, in the cross section of this feed at Fig. 19. The apron is lined with canvas to avoid the possibility of wool fibres falling between the slats, winding around

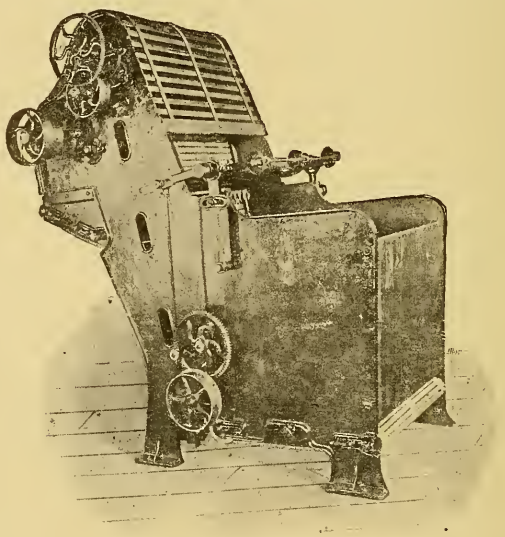


Fig. 18. High Feed

the apron pulleys and doing damage. This apron, which continually revolves slowly, forces the wool which has been placed in the hopper against the spike lifting apron, B, which in turn carries it up and past the oscillating comb, C. The surplus amount of wool is here combed off and falls back into the hopper. The balance is carried over the top of the apron to the revolving beater, D, which disengages it from the spikes and throws it off. The wool may fall upon a short rapidly revolving doffer apron, or by the action of the beater, directly into the liquor of the scouring bowl.

The spike apron is made of heavy, spiked slats supported on leather belts and protected in the rear by canvas in the manner described for the bottom apron. At a point nearly opposite the revolving beater is a binder roll, E, which makes an angle in the apron; the front of the apron and the rear not being parallel. As the beater is nearly opposite the vertex of this angle of the apron, its action is much more effective in whipping the wool from the

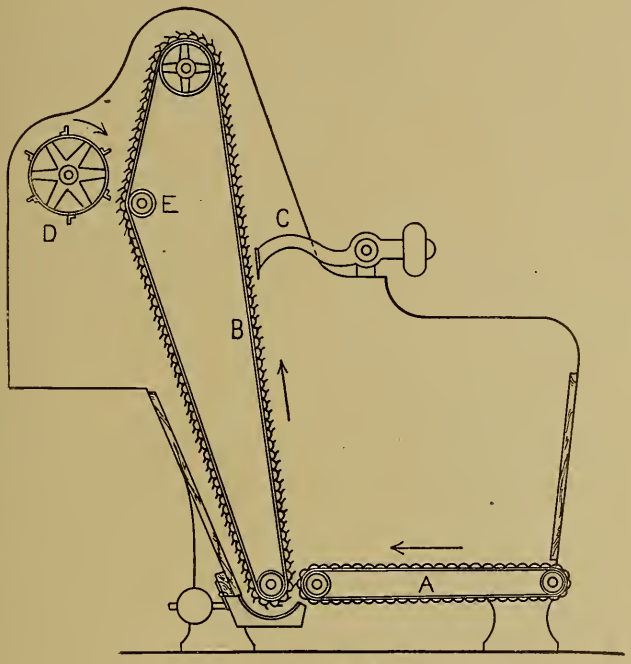


Fig. 19. Sectional View of High Feed.

points of the teeth to the machine to which the wool is to be delivered.

There are several methods by which a greater or less quantity of wool may be handled by this machine. The oscillating comb in front is capable of adjustment forward or backward, so that a greater or less amount of wool passes up the apron to be delivered, according as desired. On some makes of feeds the aprons are also allowed various speeds, according to requirements by an arrangement of step pulleys. The most important feature

of the high feed and its capability of handling long wool is in the following: It is necessary in handling long wool or fleece, that the

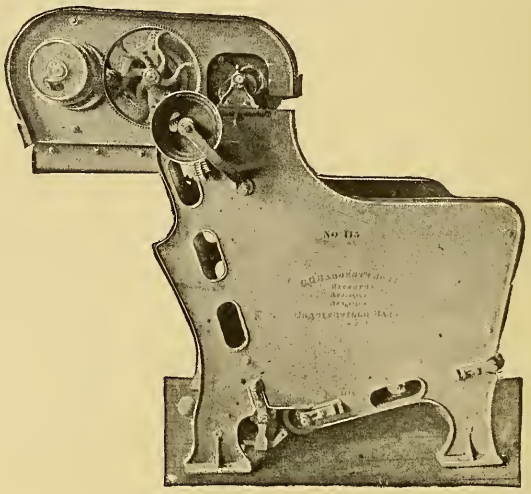


Fig. 20. Low Feed

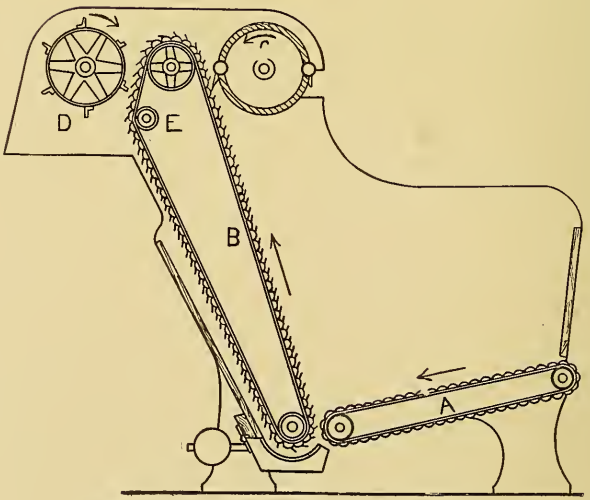


Fig. 21. Sectional View of Low Feed

distance around the top of the apron, from the comb to the beater, shall be great enough so that these two factors do not operate

upon the same fibre or fleece at the same time; otherwise, they would naturally cause breakage of staple, or clogging of the machine. The capacity of the hopper, roughly speaking, is 400 or 500 pounds, depending, of course, upon the width of the machine.

The Low Feed, an illustration of which is shown in Fig. 20, is in general method of construction the same as the preceding feed. It is intended for cotton or short staple wool, and generally speaking, may be considered as the best type of feed for the woolen mill. In the cross section shown in Fig. 21, A is the bottom slatted apron, similar in construction to the apron on

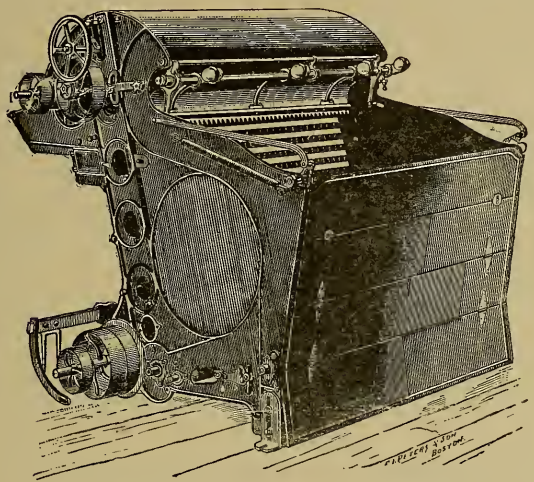


Fig. 22. Another Type of Low Feed.

the high feed. This feed is generally fitted with a revolving tooth comb C, the teeth of which after coming in contact with the wool on the spiked apron B, and combing off the surplus amount, are feathered or drawn back so as not to engage with the fiber. The oscillating comb is occasionally used instead of this form.

The spiked apron, and revolving beater D, are similar in construction. It will, however, be noticed that on account of the length of stock handled in this feed, the comb and beater are much nearer together. Variations of speeds may be effected on the low feed in a similar manner as on the high feed.

Dusting. Before presenting wool to the scouring machines and in order to free it from as much dust and dirt as possible, the Duster is used. Heavy and light dirt particles and extraneous matter are removed through two agencies; the action of the cylinder combined with the grid and the action of the air current from the fan, respectively. This machine answers not only for this purpose but opens the fleece, breaking up cotted wools, thus allowing the liquor free access to all of the fibers.

The Cone Duster. There are two forms of duster in common use, the Cone and the Square. A cross section elevation of a

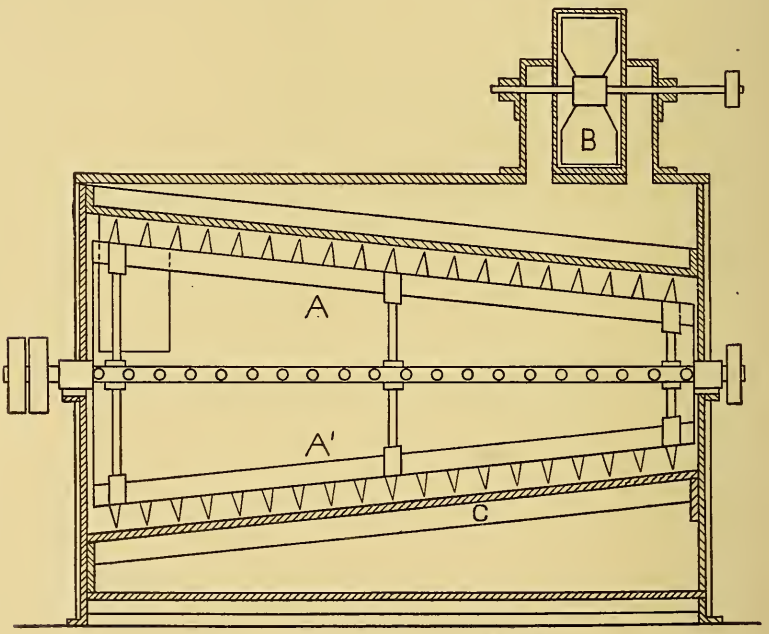


Fig. 23. Sectional Elevation of Duster.

simple cone duster is shown at Fig. 23. A and A′ indicate the cylinder which is cone-shaped, 4 ft. in diameter at the large end and 26″ at the small end. It is equipped with four lags in which are set iron teeth which mesh with stationary teeth on each side of the machine. Above the cone is the fan B, which draws away much of the lighter particles, such as straw, loose burs, chaff, etc. Below the cone at C is either a grid or screen through which the heavier particles, such as dirt and sand fall.

Fig. 24 looking down upon the machine, shows the fan at B and also the general shape of the cone cylinder. G is the apron upon which the stock is thrown either by hand or from an automatic feed. The feed roll is shown at F, and the passage through which the wool is ejected is at D. When the wool enters the machine, the cock spur teeth with which the feed roll is equipped hold it momentarily while it is beaten and somewhat opened by the teeth of the cylinder. The cylinder revolves at a speed of about 400 revolutions per minute. The bottom and sides

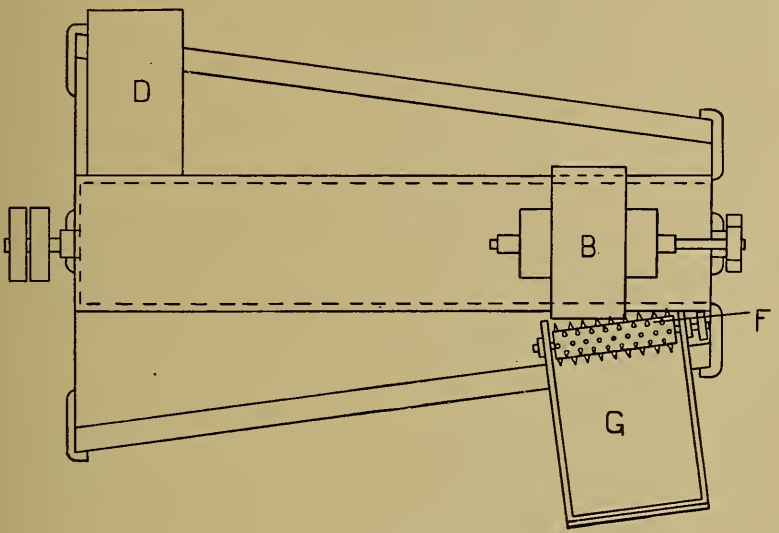


Fig. 24. Plan of Duster.

of the machine are air-tight so that the fan running at about 800 R. P. M., can draw air up through the stock through a screen situated under the fan, thus drawing away the light particles. The heavier particles fall through the screen underneath the cylinder.

A type of duster in general use is shown at Fig. 25 and is equipped with a worker roll. This roll is situated at the back of the machine and is plainly seen in this rear view. This assists materially in opening up the stock. It is detachable and when dusting medium length wools, if there is the least danger of tearing them, the worker should be removed. The arrangement of the working parts is given in the diagram Fig. 26 ; the arrows on

the rolls, pulleys, etc., indicate the direction in which they revolve while the groups of arrows show the direction of the air current. A is the apron, B the feed roll, C the cylinder, D the worker, E the fan, F the removable screen above the cylinder, and G the screen or grid below the cylinder.

There is little to say in regard to the handling of these machines, save that it is very important for the lower portion to

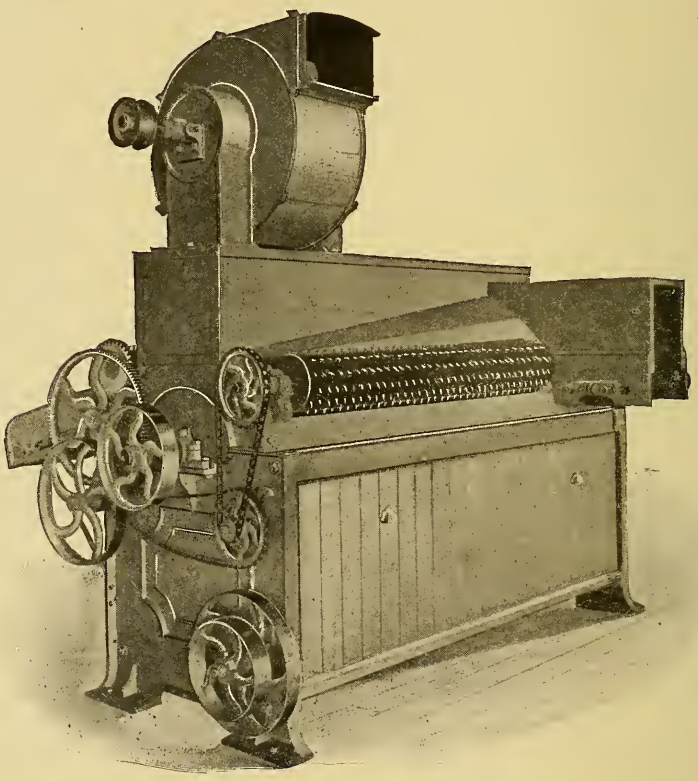


Fig. 25. Duster With Worker Roll.

be air-tight, and that dirt under the grid should not be allowed to accumulate in too great quantity. The floor space occupied by the duster is $9 \times 7\frac{1}{2}$ feet.

One of the important features of the cone duster is the fact that it makes this process continuous; the wool, owing to centrifugal force, moving continually from the feed end of the

machine to the outlet. This is, of course, due to the cone-shaped cylinder.

Fig. 33 on page 56, the carbonizing duster, is in its essential features much like the cone duster already described and is referred to at this point owing to the fact that the front of the machine is open and shows the screen under the cylinder, a por-

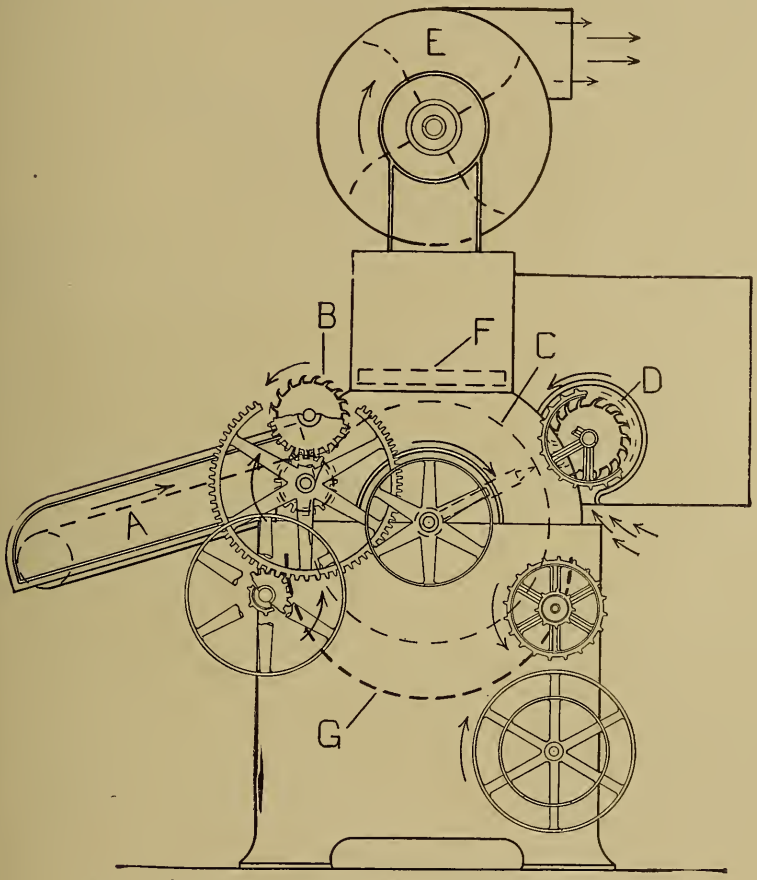


Fig. 26. Sectional View of Duster, Showing Working Parts.

tion of the cylinder itself, and also the swing door underneath, through which the dirt is taken from the machine.

The Square Duster shown in Fig. 27 is based on an earlier form of machine. The stock after being received upon the apron passes between rolls and thus into an ordinary square spiked cyl-

inder, which performs much the same duty as the cone cylinder, save that the stock must be taken out by hand, thus preventing a continuous process.

Wool Scouring Machinery. Owing to the peculiar structure of wool fiber, it must have no violent treatment or unnecessary agitation after it has been placed in the scouring bath, as it is subject to injury by the manipulations of the scouring machine, felting by pressure and friction during the wet state ; and that to get an open, free, and lofty wool, it must be only sufficiently

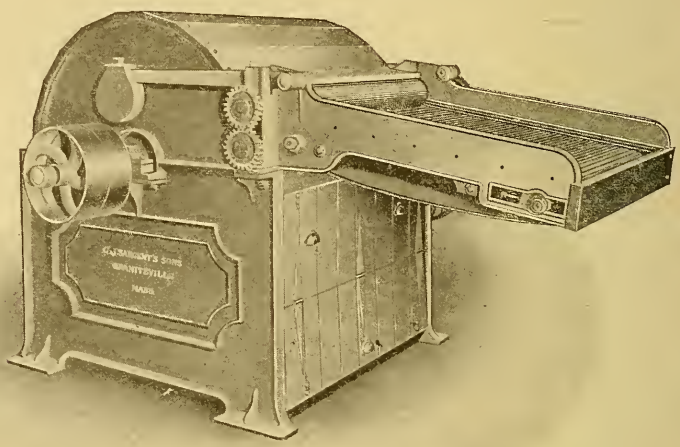


Fig. 27. Square Duster.

agitated to cleanse it thoroughly. Therefore, it is the duty of the manufacturer to open and free it from as many impurities previous to scouring as it is possible for him to do.

Scouring machines have been vastly improved during the last fifty years, Fig. 28 illustrating an old form in use many years ago. It consisted of a tank in which the wool was prodded with poles to keep it in motion, and a squeeze box and lever for extracting from it afterward some of the surplus water or scouring liquor. The production by means of this primitive method was only a few hundred pounds per day.

The Parallel Rake Wool Washing Machine shown at Fig. 29

is a common form of washer in use today, 16 ft. in length, and which is known as the Parallel Rake Motion Wool Washer. The bowls of a wool washer are built in various lengths according to the needs of the plant. The general sizes are 16 ft., 21 ft., 27 ft., 32 ft., and 37 ft., and also in several widths; 24″, 36″, and 48″. Scour-

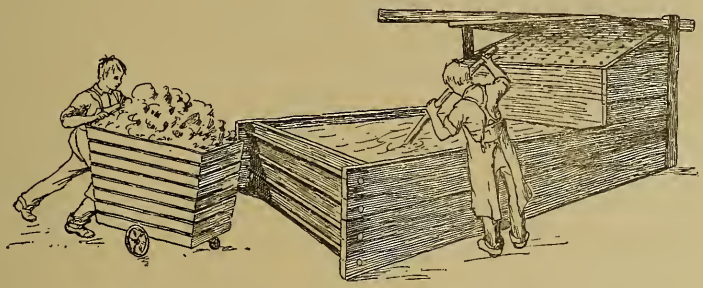


Fig. 28. A Scouring Machine of Fifty Years Ago.

ing trains are built in different combinations of bowls — one in front of another, depending upon the amount of wool to be scoured. A combination of bowls frequently used in mills scouring about say 15,000 lbs. of greasy wool per day, 50% shrinkage, is four bowls 48″ wide consisting first of a 37 ft. bowl, second, one of 27 feet and the other two 21 ft. each, in which the first two bowls are

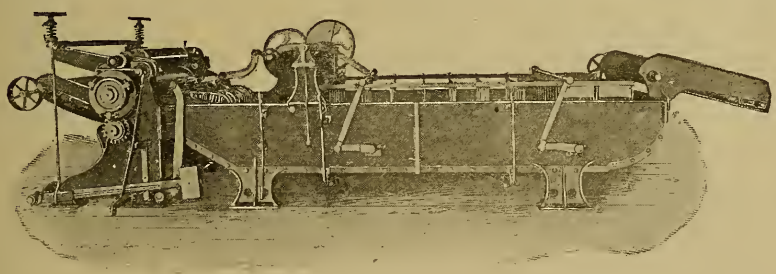


Fig. 29. A Modern Type of Sixteen Foot Bowl.

used as "*Scourers*," having the soap solution contained therein, and the last two bowls piped with overflows for running water and used as "*Rinsers*."

Another very good combination for a washing machine is three bowls; the first one 32 ft. in length and the others 24 ft. each. In the carpet yarn trade, there are combinations consisting

of four bowls. First bowl 37 ft., second and third bowls 32 ft., fourth bowl 27 ft. This makes a string of machines 125 ft. long and will scour about 20,000 to 24,000 lbs. of greasy wool per day.

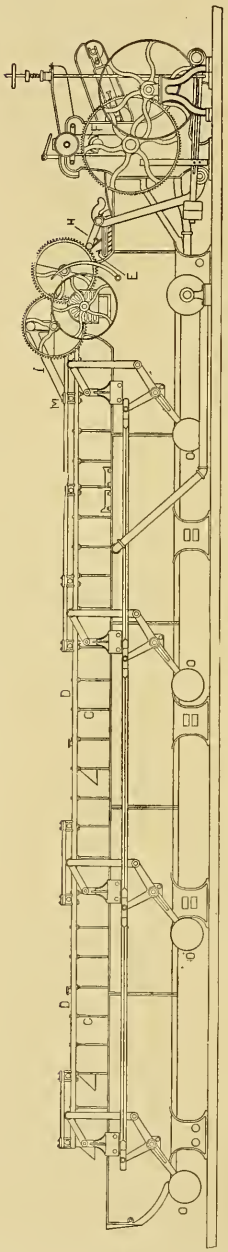


Fig. 30. Parallel Rake Scouring Machine Showing Working Parts.

After the wool is thoroughly dusted, it is thrown into the hopper of the self-feed, which delivers it evenly into the feed end of the wool washing machine. Oftentimes no self feed is used on the washer, in which case the wool is fed by hand on the traveling apron. In using the automatic feed, the feed apron is dispensed with, and the wool drops from the doffer beater directly into the scouring liquor in the first bowl, and is immersed by the ducker plate. This is a hollow rectangular basket of sheet copper with perforated bottom; Fig. 30.

The wool is now carried along through the liquor by means of the rakes, C C, hanging vertically, and attached in parallel rows to the rails D D by means of the rake heads. It is very desirable that the wool shall travel along with as little agitation as possible, particularly with combing wools, and it is the duty of the men in charge to handle the wool in such a manner that it may not become roped, felted, or stringy. The "parallel" motion of this machine meets these requirements. Machines of this description are known as "parallel rake," not from the fact that the teeth or forks are arranged in parallel rows, but from the orbit or path in which any point, say the tips of the teeth, travel. The teeth enter the liquor in a vertical direction, till the points come within a quarter of an inch of the

copper perforated false bottom, when they change their direction of motion to a forward one, that is, parallel to the false bottom, and the surface of the liquor. After traveling ahead in this horizontal line fourteen inches, they withdraw from the liquor in a vertical line or at right angles to their forward motion.

After the teeth are wholly out of the liquor, they go back to their former position in the arc of a circle describing a semi-circumference. It will thus be seen that the motion of the rakes while in the liquor is rectilinear, and not circular. The object of this as previously stated is to avoid the possibility of roping, felting or stringing the wool.

The wool after passing the length of the bowl arrives at the carrier E, which delivers it to the press rolls F. The carrier is an arrangement of brass fingers or forks which have a forward and backward motion. In its forward motion it carries the wool ahead over a perforated brass table and in its backward motion it lifts over the wool until it arrives at its former position, and moves ahead with a fresh supply. The carrier is actuated by a crank H which has a 7″ throw. This makes 4 revolutions to one of the rake crank I. That is, the carrier runs 28 motions per minute. On the end of the carrier crank shaft is a gear of 118 teeth. Also on the end of the rake shaft is a gear of 144 teeth. These gears run independently but are each driven by two smaller gears on a side shaft below and between them — the 118 tooth gear meshes with a 60 tooth, and the 144 tooth gear meshes with an 18 tooth gear. On the side shaft there is also a 24″ tight and loose pulley which drives direct from a 12″ pulley on a countershaft running 113 revolutions per minute. Thus the side shaft runs $56\frac{1}{2}$ revolutions, and runs the carrier 287 R. P. M. and the rakes 7.06″. It will be noticed that the rake crank I drives the rake by the crank pin working in a slot of connection M. It is this arrangement which causes the rake to travel ahead horizontally upon the roller tracks N.

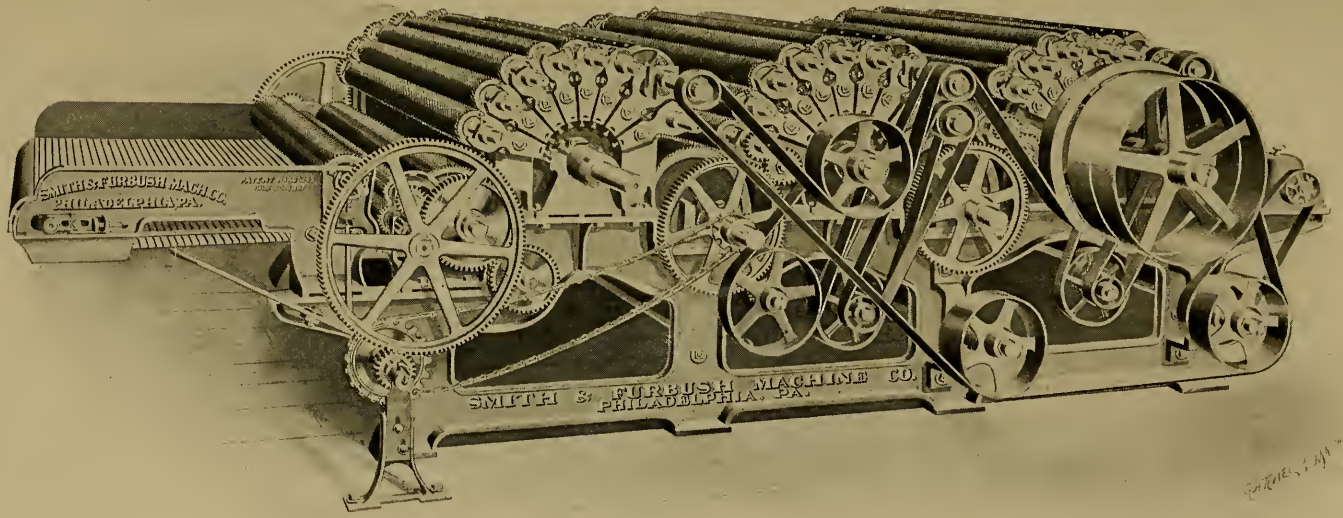
The weight of the rake is counterbalanced by the weights O. The level of the liquor in the bowl is three inches from the top, and the bite of the nip rolls is on this level. By having the rolls low in this manner, the wool goes to them with the fiber open and full of liquor. The old style of having the rolls high, and the

wool carried up to them on a steep incline out of the liquor, was considered detrimental to the wool, as it had a tendency to felt it. With the bite of the rolls low (although the rolls are entirely separated from the liquor by a water-tight girt) there must be some provision for the liquor which is squeezed out of the wool in passing. This is arranged for by the pan or girt into which the liquor flows. From this pan a small pump on the floor beside the machine sends the liquor back into the bowl, generally into the end of bowl at the feed. The bowls are connected by steam injectors so that when the liquor gets worthless in the first bowl valves are opened in the side (two valves for 16 ft. bowl, three for 21 ft. bowl, and four for 27 ft. bowl, etc.) and the liquor is thrown away. The injector draws the liquor from the second to the first bowl, from the third to the second, and from the fourth to the third. After passing through the heavy squeeze rolls, which vary in weight from 1050 to 1250 lbs. each, and with a pressure of 8 to 10 tons on the top roll, the wool is delivered from the doffer apron into a truck to be carted to the dryer or dye house, or preferably into a conveying apron which automatically carries it into the self feed of the dryer.

If it is a two bowl or longer train washer, after passing the rolls the wool is delivered by the doffer apron into the next bowl. In woolen mills, the last two bowls are generally supplied with running water to rinse the wool of particles of soap or alkali carried from the first bowl.

With the train of machines shown in Fig. 15 the wool can be dusted, scoured, rinsed and dried by the labor of one man with possibly a helper with no intermediate handling from the time it goes into the self feed of the duster until it comes out of the dryer ready for the cards or pickers.

Wool Degreasing. There are various processes for degreasing wool and for the recovery of the fatty matters contained therein, none of which, however, are in very extensive use in this country. The wool is placed in a wire carriage and run into air-tight cylinders on trucks, the air then being extracted from the cylinders. After this, gasolene is run into the tanks and by means of a steam coil the pressure is raised to about 15 lbs. The gasolene is now drawn away and the stock freed from it as much as possible



THREE CYLINDER GARNETT MACHINE
Smith & Furbush Machine Co.

before going into the deodorizer, a hooded machine built something after the manner of a wool dryer. Here steam and air are forced through the stock, by which process all of the gasolene is removed. The wool is now scoured, but with much less soap than would ordinarily be used. The gasolene is afterwards distilled to free it from the yolk or suint which it contains.

Flume or Rakeless Washer. This type of machine though not in general use is in operation in some plants. The machine takes the name of flume washer from the fact that the liquor is discharged from the trough back into the lower bowl, propelling the wool without forks or rakes; Fig. 31.

A is where the liquor is mixed and the wool goes into the bowl.

B is the pump located below the water line, and a few inches above the bottom of the bowl.

C is the trough from which the liquor is pumped. This trough has catcher boxes D where the sediment is caught. The valve is open and the contents of the boxes discharged into the bowl A and from there into the sewer.

E is a fluted roll which revolves slowly, passing the stock forward to the carrier; it also keeps the liquor at the right height in the trough C.

F is the copper ducker which travels or swivels on pipes G. These duckers have a forward, up, back and downward movement by crank H and I. Near the extreme end of the machine is a carrier, which passes the stock to the squeeze rolls. K is a small catch box, under the squeeze rolls, with perforated copper piece near its top to catch any stock which may drop from the rolls. The sediment which is squeezed from stock is caught here, and the good liquor returned to bowl A to be used over again. The grease rises to the top of the liquor, and is retained in the bowl and does not come in contact with the stock. The stock as it floats through the trough is immersed by the duckers and as they are made with the swivel movement, they give the stock a slight squeeze on the bottom, and as they lift, push it forward.

Referring to the liquor being kept at its proper level which is about 7 inches above the false bottom; in the trough there is an overflow on the sides, taking the surplus water from under the false bottom so that no wool can escape.

The top press roll is covered with rubber or lapping and is 14″ in diameter, which is also the diameter of the bottom roll. These rolls weigh about 1000 lbs. each, and the pressure is 14 tons when the weight and connection are out at the extreme ends. The duckers travel about 10 inches, and make eight revolutions per minute. The speed of the rolls is 10 revolutions per minute. The top roll is driven by friction, but when any bunch of stock stops it, the ratchet works and drives it. This ratchet is used because the diameter of top roll is changing as the rubber or lapping wears off.

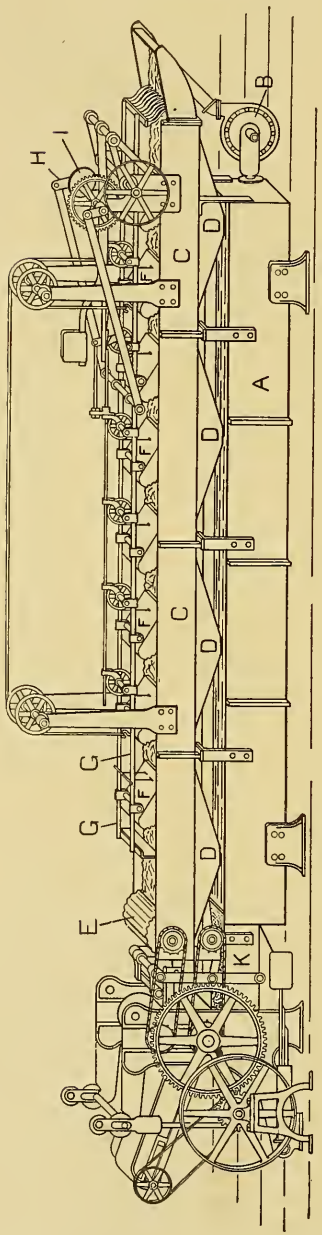


Fig. 30. Flume Washer.

Wool Scouring. One of the most important processes and one of the first operations in woolen and worsted manufacture is the washing and cleansing of wool, the correct performance of which is of more consequence than is generally imagined by those who are not well versed in carding, spinning and dyeing. Scouring as applied to wool, implies a more scientific and skillful treatment than a simple washing. It is one of the most essential and important branches of the woolen and

worsted trades, besides requiring on the part of those in charge of the department, a thorough knowledge of chemistry, as far as applicable to the subject, and also a wide experience.

The scouring of wool is the cleansing of it, from its yolk, natural grease, dirt, and other extraneous matter, with which it may be impregnated. The aim in accomplishing this is to pro-

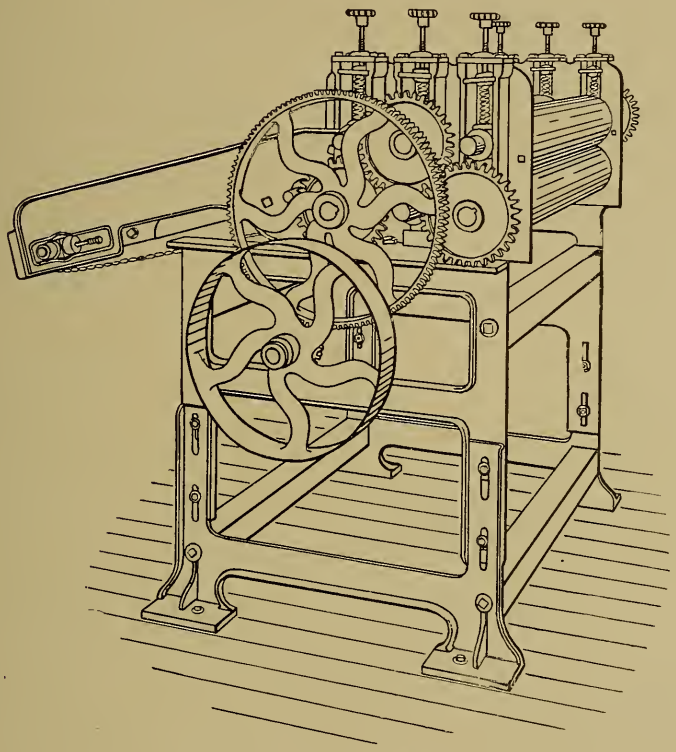


Fig. 32. Crush Roll Machine.

duce a perfectly clean fiber, the delicate scales of which are uninjured.

The water used for scouring should be analyzed, in order that its action on the soap may be determined, and remedied if necessary; for unless the wool be well scoured and cleansed from the yolk and grease the subsequent operations will be materially effected. The cleansing of wool from all foreign and extraneous matter previous to dyeing, is of the utmost importance, and a neces-

sary preliminary to the production of good colors and brilliant shades.

There are several reasons why wool should not be subjected to violent agitation in the washing machine. As is well known, wool readily lends itself to the process of felting, that is, forming itself into a solid mass when subjected to moisture and pressure, and more especially when soap or other substances of that character are present. The locks and fibers become matted together, and there is difficulty in dyeing and carding afterward. The delicate structure of the wool fiber consisting of the scales or serrations can be injured only too easily. Wool is impregnated with yolk or suint, a yellow oily substance caused partly by the accumulated sweat, and partly by a secretion from the glands of the skin which lie at the roots of the fibers.

This secretion covers the fiber from root to top and takes the form of an oily varnish. Yolk or suint is most abundant on sheep in hot climates, and prevails to such an extent that the clean wool is often only one third of the original or natural weight.

Wools vary in the composition of foreign and external matter. In addition to yolk there are other substances that go to make up the weight of the fleece. A merino fleece is said to be constituted as follows:

Earthy substances	26.06
Suint or Yolk	32.74
Moisture and Fatty matter	8.57
Matter fixed by grease	1.40
Clean fiber	31.23
	100 00

German Wool:

Mineral matter	6.3
Suint or Yolk	44.3
Moisture	11.4
Clean fiber	38.0
	100 00

HUNGARIAN WASHED WOOL:

Mineral matter	1.0
Suint or Yolk	27.0
Moisture	7.2
Clean fiber	64.8
	100.00

The yolk consists principally of potash and animal oil; carbonate of potash, lime, acetate and muriate of potash are also contained therein and is of much value in softening and preserving the wool while it is growing, for it oils the fibers and keeps them from matting and felting. This enables the sheep to keep warmer, and tends toward producing sounder and healthier wool.

As scouring should be done without injury either to the physical structure, or chemical composition of the fibers, the work must be accomplished by the mildest means possible, so that the scales will not be injured either by too great heat in the water, the use of too strong alkalies, or by excessive pressure, manipulation and violence in the scouring machines. Thus according to the wool in process, softness, strength, lustre and brilliancy must be retained. A wool thoroughly cleansed is white, soft, elastic, open and lofty, so that it dyes readily, and in the succeeding processes cards and spins into a level thread and ultimately produces a full soft velvety fabric. If these necessary features are destroyed by any harsh treatment the fiber is rendered hard, unpliable, and hask; it also deteriorates in strength and the luster is impaired as these qualities are destroyed in the wool, and so is the quality of the fabric that is made from the same wool injured.

Wool can be almost cleansed in water alone, and if it were not for the oily and varnish like matter that adheres to the outer surface of the fiber, it could be thoroughly cleansed in a running stream of cold water. But as this is always present in greater or less quantity, warm water and soap must be resorted to. The use of water too hot, or the excessive use of alkalies must be avoided for they will not only remove the suint and free oil which is associated with it, but the heat and alkali will attack the fatty substances of the structural cells, and thus render the fiber hard and brittle, and destroy the life of the wool.

Strong alkaline solutions easily dissolve wool, therefore, when using alkalies or alkaline salts, with hot water, the greatest care and skill must be exercised. The fiber scales when treated only with tepid water, lose some of their luster and brilliancy, and when treated with boiling water, 212° F, the lustre is still further diminished. If boiling water is superheated to 230° F., it will decompose wool, therefore when wool is placed in water which is at the boiling point it is within 18° (F.) of heat from the point of its destruction. With these facts in view there is no difficulty in comprehending how important it is to know the temperature of the water, its quality, and the strength of the alkalies.

Borax, bi-carbonate of soda, and carbonate of ammonia are substances which effect wool fiber very little and can therefore be used as cleansing materials; scientifically known as detergents. Soda is sometimes employed as a detergent; it destroys some of the life of the fiber, and instead of acting as a bleaching agent, imparts a yellow tinge to the wool. It can, however, be used without much injury to the fiber if the quantities and temperature are properly regulated. A cleansing solution composed of bi-carbonate or sal soda, common salt and ammonia in the first bowl, will be found effective, though which might, if nothing else were used, leave the wool a little harsh. To counteract this, use a small quantity of olive oil and caustic potash in the water of the last bowl in the train.

Potash has a better effect than soda (carbonate of sodium) as there is a small quantity of this detergent in the fibre, and potash is the alkali naturally most suitable for whitening and bleaching the wool. In scouring wool with an alkali, a volatile and not a fixed alkali should be used. The temperature of the washing liquor should never be permitted to exceed 120° F.

Soaps are generally resorted to as the scouring agent. Only perfectly neutral soaps should be used, and those in which potash enters should invariably be chosen. Soda soaps are more energetic, but as they have a tendency to destroy the small filaments or serrations of the fiber, they should be used with extreme care or not at all, as they are detrimental to the production of perfect fabrics.

The following recipe for potash soap has been used in this

country in various mills with very good success. Dissolve 400 lbs. of caustic potash in about 100 gallons of water. Boil until all is thoroughly dissolved. Add enough cold water to make up 400 gallons. This equals one lb. of potash to the gallon of water. Let the mixture cool until the temperature is normal, say between 60° and 70° F, when it will stand at about 14° Twaddle. Run this lye into barrels and to each 40 gallons add 10 gallons of red oil. Stir occasionally until the ingredients combine, and a soap somewhat the consistency of thin jelly will form.

For scouring, take 125 lbs. of this soap, 199 lbs. of pearl ash, and boil in 250 gallons of water until the mixture is thoroughly dissolved.

In applying the above, very greasy wools require from ten to twelve pails in each of the two first bowls (16 ft. bowls) and water in the third and fourth bowls. The man in charge of the scouring must by actual experience or tests determine the strength of the liquor for the cleaner grades of wool.

As the soap manufactured for use in woolen and worsted mills is easy of adulterations which are hard to detect, it should not be purchased without exhaustive tests and trials under most careful supervision.

A receipt for testing soap is to dissolve one ounce in a given quantity of water, put it into a long test glass and add a quarter of an ounce of diluted Sulphuric acid. The acid neutralizes the alkali ; the grease and resin, if any, will float on the top while the earthy matter will fall to the bottom.

The quantity of water in soaps may be ascertained by reducing a sample of a given weight to parings and placing in a hot oven, in which it should be allowed to remain until it ceases to become lighter, when the difference between its original and dried weight will indicate the percentage of water evaporated. Other adulterations may be detected by immersing the soap in a strong solution of alcohol, and applying heat, which dissolves the soap and leaves the impurities insoluble.

The next question is the purity of the water. The hardness and softness of water is a matter of vital importance, and varies according to the proportion of salts, lime, chalk and other mineral substances it may contain. When hard water is used for scour-

ing purposes without being previously softened, the lime it contains, in many cases, destroys and precipitates the dye waves, and in all cases immediately attacks and decomposes the soap used; the soda or potash with which the soap is made, leaves the oil and tallow with which it has been combined, and unites itself with the carbonates and sulphates of lime, thus forming an insoluable

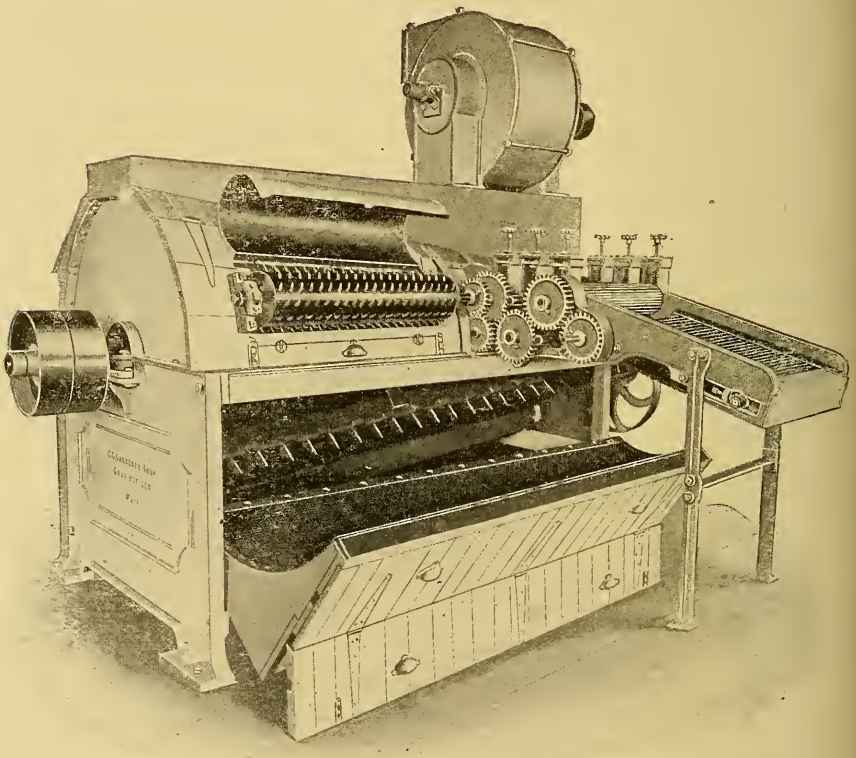


Fig. 33. Carbonizing Duster.

lime soap, a compound perfectly useless as a scouring agent. This insoluble lime soap has often a most disastrous effect on goods which have to be dyed, causing spots and uneven dyeing, owing to the lime soap sticking to the fibers in the fabric, and in many cases being only partially removed by subsequent washing. It is clear that the soap can have no effect on wool until the lime in the water has finished its work, and is entirely united with the

alkali of the soap; then the washing begins, but now the soap has to wash out, not only the original dirt from the wool, but also the lime soap, which has settled on it.

Water Tests. Boil 1 gallon of water until only a small amount remains, add to this residue a few drops of muriatic acid. If the acid dissolves with effervescence the water is hard. Sulphate of lime will remain.

A drop or two of Gallic acid will detect iron in water that has been boiled in this manner, by giving it a black or bluish tinge.

A pure white soap dissolved in alcohol in such proportion as to form a jelly, if placed in hard water will curdle, but in soft water will not curdle.

The following tests may be made with a small quantity of clear boiled water; divide the water into five parts for as many tests:

1st. If lime is present, oxalate of ammonia (a few drops) will cause a white precipitate. The water should be heated in this test and should stand a short time after the acid is added.

2d. Sulphuric acid is present if after using chloride of barium a white precipitate appears which will not be redissolved by nitric acid.

3d. Magnesia is present if by adding carbonate of soda a white precipitate forms after standing for a short period.

4th. Hydrochloric acid is present if by using nitrate of silver a white precipitate forms which will not be redissolved by nitric acid.

A general method of softening water for wool scouring consists in collecting it in large tanks, when from two to six pounds of refined carbonate of potash per 1,000 gallons of water is added, which in a very short time precipitates the lime, and leaves the water ready for use.

Sometimes the potash is added in the scouring machine previous to introducing the soap into the solution, but the former seems to be the more preferable plan. A quarter of an ounce of powdered caustic soda per gallon is enough for the hardest water. It acts equally well when the water is cold, and rendering the lime insoluble, precipitates it along with any lime or magnesia

salts that the water may contain; it should, of course, be put in before the soap is added, or the benefit is lost.

Neglect of all these principles will be found out in the after processes, such as dyeing, carding, spinning and finishing. If unsuitable soaps, oils, temperatures, both moist and dry, are used in absolute neglect and forgetfulness of the fact that the delicate fibres need all their porosity and original surface luster to receive various shades and delicate tints, the loss is incalculable. Under these circumstances, in the mill and factory it is not strange that certain goods come up wrong, with parts of the warp and filling not alike, or that certain shades are fugitive and change color, and everyone concerned blames everyone else in a vicious circle.

Hydro-extractor. In many mills after scouring, the hydro-extractor is employed to extract the rinsing water from the wool. This machine is not used for raw stock in all mills, as the wool oftentimes goes direct from the sqeeze rolls of the last scouring bowl into the automatic feed of the dryer.

A convenient form of extractor is shown in Fig. 34. Its operation is as follows: The wool is placed in the perforated basket, A, around which is a curb or outer casing of wrought iron, D. The basket is placed upon a spindle, C, and is actuated by the belt, M. It will be noticed that the cast iron bed plate of this machine, K, rests upon a stone or brick foundation. The lever, L, is used in starting or stopping the machine. The brake shoe, B, acting upon the pulley, N, is effective in stopping the basket after the stock has been extracted. The water is extracted from the wool by means of centrifugal force as the rapidly revolving basket throws the water off against the curb after which it travels down through pipes under the machine and thus escapes.

The 36″ basket runs at about 1,000 revolutions per minute, while a larger basket, 42″ in diameter, is run at about 870 revolutions. Some 4,000 lbs. of stock can be run through the larger machine in a day of ten hours.

Drying. The drying of wools after their leaving the scouring machines have met with more radical changes during the past twenty years than probably any other part of woolen yarn manufacture. The table or screen dryer is still in use in many mills today, but has been largely superseded by machines of the con-

tinuous type. With the screen dryer, the material to be dried was placed by hand and removed in the same manner, on a table covered with a screen and shaped somewhat like the low pitched roof of a house. A blast of either hot or cold air was forced up through the mass of wool lying upon the table. Although numbers of these machines are in use today in mills, the later types of machines will be given the preference in the following descriptions:

As already shown in the arrangement of scouring and drying

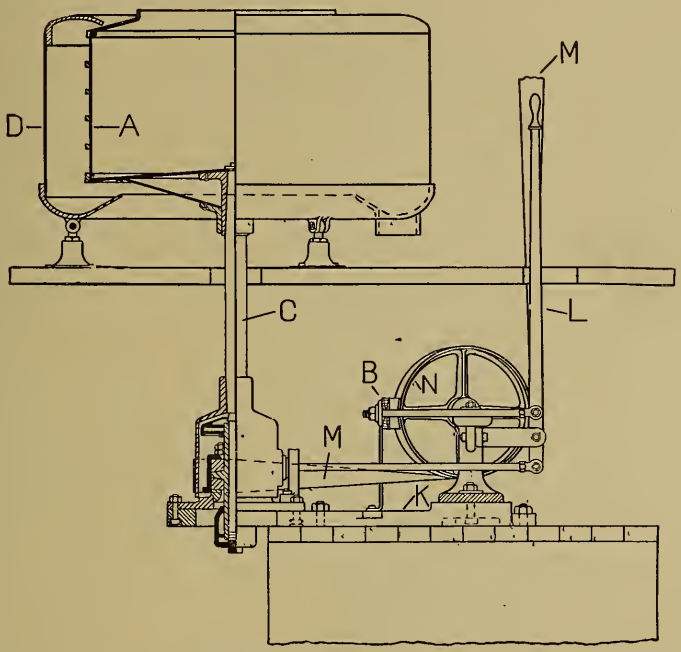


Fig. 34. Hydro-extractor.

trains, dryers are frequently directly attached so that the doffer apron on the last bowl of the washer delivers the wool into the automatic feed of the dryer; so that there is no handling of wool necessary from the time it is placed in the duster or washer feed until it emerges from the dryer scoured, rinsed and dried.

The One Apron Dryer. The one apron dryer is built in a number of sizes with capacities ranging from 1,200 to 12,000 pounds of wool per day. In width the apron varies from 4 to 10

feet, according to the space and capacities required. The machine is built in sections or compartments each of which is 15 feet long. Fig. 35 shows a two section or 30 ft. dryer. Owing to this divi-

Fig. 35. One Apron Dryer. Two Sections.

sion of the machine into compartments the temperatures may be sub-divided.

A cross section and plan of this dryer is shown at Fig. 36. The compartments which contain the coils of pipe are shown at A

and B. Compartment A contains a coil of $1\frac{1}{4}$-inch pipe 1,092 ft. in length. The coil in compartment B is 819 ft. in length. In other words, in a two section machine about 60% of the total amount of pipe is in the first coil, and the balance or 40% in the second coil. This principle is carried out should the dryer be built 3, 4, or 5 sections in length so that the highest temperature is presented to the wool at or near the feed end of the machine where the material to be dried contains the greatest amount of moisture, therefore resulting in less liability of injury to the stock.

Fresh air is taken through the inlet C at the doffer end section opposite the last fan and the moist air is taken out at the feed end section opposite the first fan. (See Fig. 37 A). It will be observed from this that there is a continual current of air, moved by the fan C, passing alternately through the stock and the coil and moving in a helical direction (like the thread of a screw) constantly toward the feed end of the machine, forcing the moisture back and out through its proper opening as described above. This is a very essential point to the proper treatment of the stock to be dried.

Another point of vital importance is shown on this machine in the conduits, D, D′, D″, or by-passes, represented in Fig. 36. Reference to the arrows in the sectional elevation Fig. 37, shows the object of these conduits, marked in this instance B. The ordinary method of circulating the air in the one apron type of dryer is down through the stock, up through the coil and so on continually with a certain amount of moist air to pass out and a small amount of fresh air to enter. It is not good policy, of course, to take out all of the air which the fan circulates for the reason that the fresh air entering the machine is naturally at a low temperature and although dry, does not have the ability to absorb as much moisture as hot air, even though containing a small amount of moisture. Therefore, the outlet has a regulating door admitting of a maximum or minimum amount of moist air to be discharged from the machine.

The old method of circulating the air, namely, through the stock and through the coils alternately, while giving fair results is very materially improved upon by the method already cited of

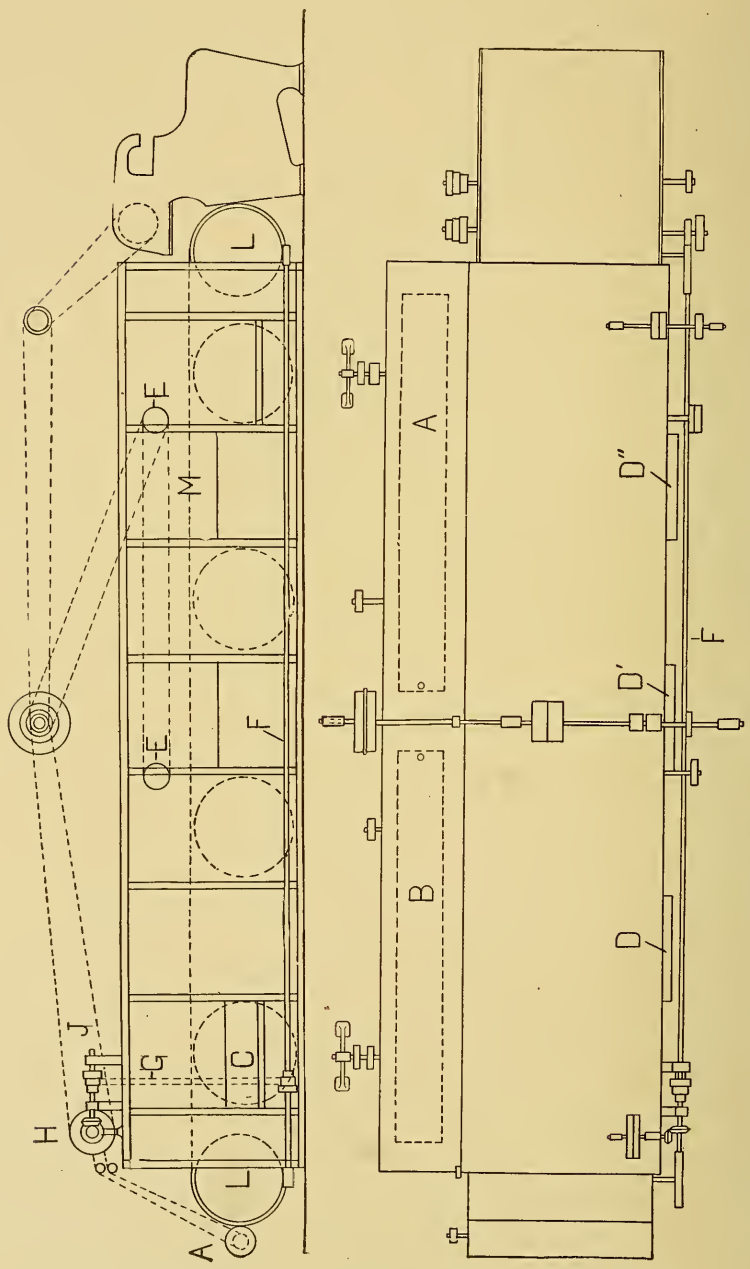


Fig 36. Plan and Sectional Elevation of One Apron Dryer.

passing a portion of the air over the stock, through the conduit or by-pass, and then under the stock to the fan already referred to. This gives three directions of air circulating, namely, through, over and under the wool. It admits of a very free circulation, and will consequently dry a large amount of wool and move considerable air without increasing the speed of the fans, which latter calls for an increased amount of power.

The elevation seen at Fig. 34 shows the apron drums L and L′ which carry the apron M. Above this are two pulleys, E and E′, which drive the revolving tedders. The purpose of these tedders is to agitate the stock and turn it over on the apron, exposing a

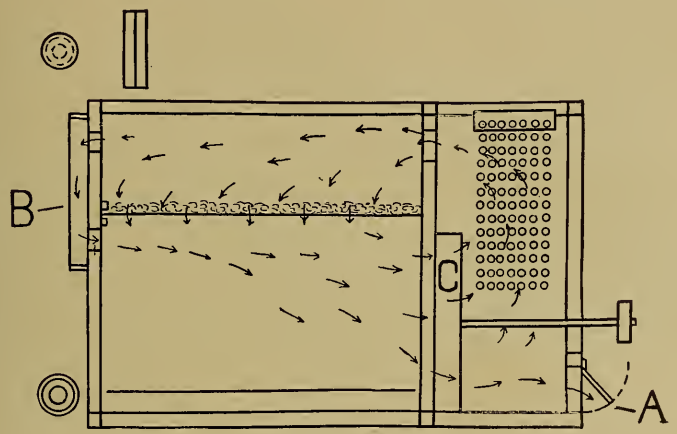


Fig. 37. End View of One Apron Dryer.

different surface to the action of the circulating air. An automatic feed is generally connected to the dryer and may be considered a part of the machine, inasmuch as it assists materially in the evenness with which the stock is dried. The side shaft F, running along the side of the machine, drives both of the large 34″ drums over which the wire cloth apron travels. An ordinary method is to drive only the doffer drum, allowing the apron to act as a power transmitter or belt to drive the first drum. In practice it has been found better to use the wire cloth aprons as conveyers of the stock only, rather than as transmitters of power.

The stock in passing from the feed falls directly on to endless

wire apron and passes slowly into the drying compartment where it meets with the heated air circulated as heretofore described.

The vertical belt G, drives the side shaft at the doffer end, and admits of a range of speeds sufficiently great to allow of rapid or extended drying as the stock may require. A shipper is also provided, shipping the belt, driving the 12″ tight and loose pulleys H, on the bevelled gear shaft J, so that the dryer apron may be stopped while the fans continue to revolve. Thus, if necessary, the machine may be charged with wool, shut down and the stock continue to dry by the action of the currents of air from the fans.

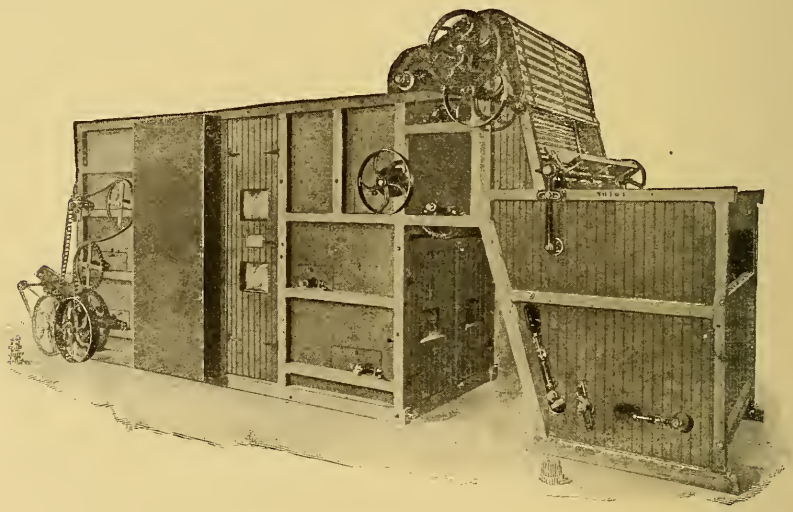
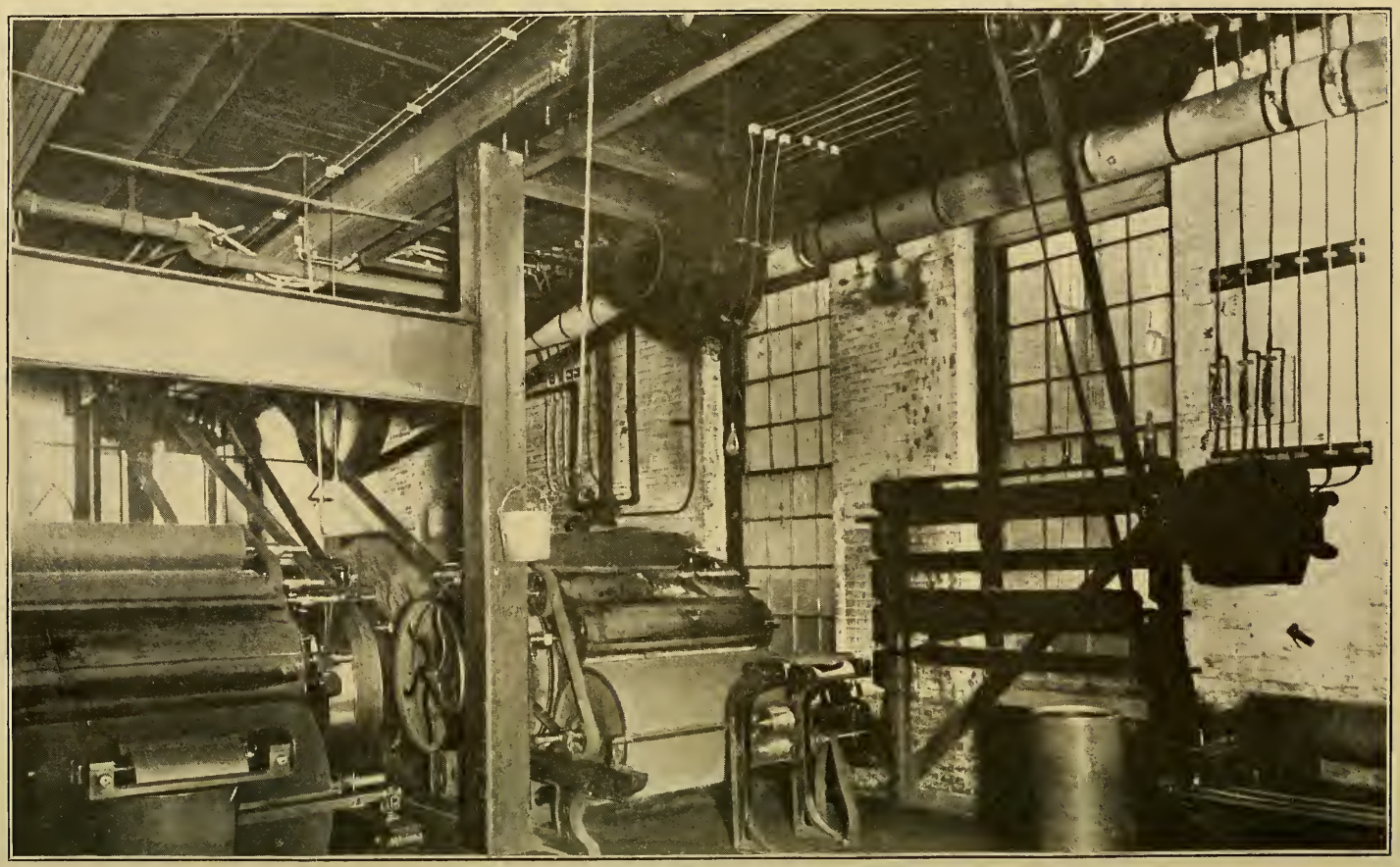


Fig. 38. Three Apron Dryer.

The roll K at the doffer end driven from the main line over the idlers, acts as a beater or doffer to strip the doffer drum and lofty the stock.

The Multiple Apron Dryer. Another type of dryer is that in which the wool or other material to be dried passes at least three times through the drying compartments, and at the end of each passage as it falls to the next apron below, is turned over, presenting its other surface to the action of the circulating air. This precludes the necessity of using revolving tedders or kickers. It also allows of a greater capacity machine in a given length and



40 H. P. INDUCTION MOTOR DRIVING WORSTED CARDS

M. J. Whittall Co.

width, although, of course, the machine requires more height than the one apron type.

A view of this dryer is shown at Fig. 38, while the elevation and ground plan at Fig. 39 give a comprehensive view of its working parts. The wool to be dried is placed in the hopper of the automatic feed in the usual manner, that is, by hand or from the doffer apron of the last bowl. It is elevated by the spiked apron of the feed, and doffed off the rear portion of the same by a doffer roll directly on to the top traveling wire apron A, which conveys it to the doffer apron on to the next lower apron B, placed directly beneath the first, and which carries it back to the feed end of the machine. At this point it drops to the bottom apron C and travels again to the doffer end of the machine, and on to a small apron D, which delivers it away from the machine into a truck, sheet or suitable receptacle, but preferably into an automatic conveying system.

The coil boxes containing the steam pipe and fans are placed along the sides of the drying compartments at E and E^1. The coils are built above the fans, the air being circulated alternately up through the wool and down through the coils as shown in Fig. 40, a portion of the moist air escaping at the doffer end of the coil boxes. Thus as in the one apron dryer, the air travels from the dry to the moist wool. The fan is shown at A. These dryers may also be run successfully with the currents of air going in the other direction, that is to say, sucking down through the stock instead of blowing up through it; in which latter case, however, the inlets and outlets are placed in different positions.

Like the preceding dryer this machine is built in various sizes with capacities ranging from 2,000 to 15,000 lbs. of dry wool per day, it of course, being understood that fine, close lying wool will not dry as rapidly as coarse and lofty stock, for the reason that the air cannot penetrate the mass of fibres as readily.

The capacity of a dryer may be increased by the addition of steam pipes, and also by increasing the speeds of the fans. This also depends somewhat upon the condition of the wool going to the dryer. Wool coming from a hydro extractor contains ordinarily from 5 to 10% less moisture than wool coming from a set of press rolls from the wool washing machine, and will consequently dry much more rapidly. The disadvantages, however, of

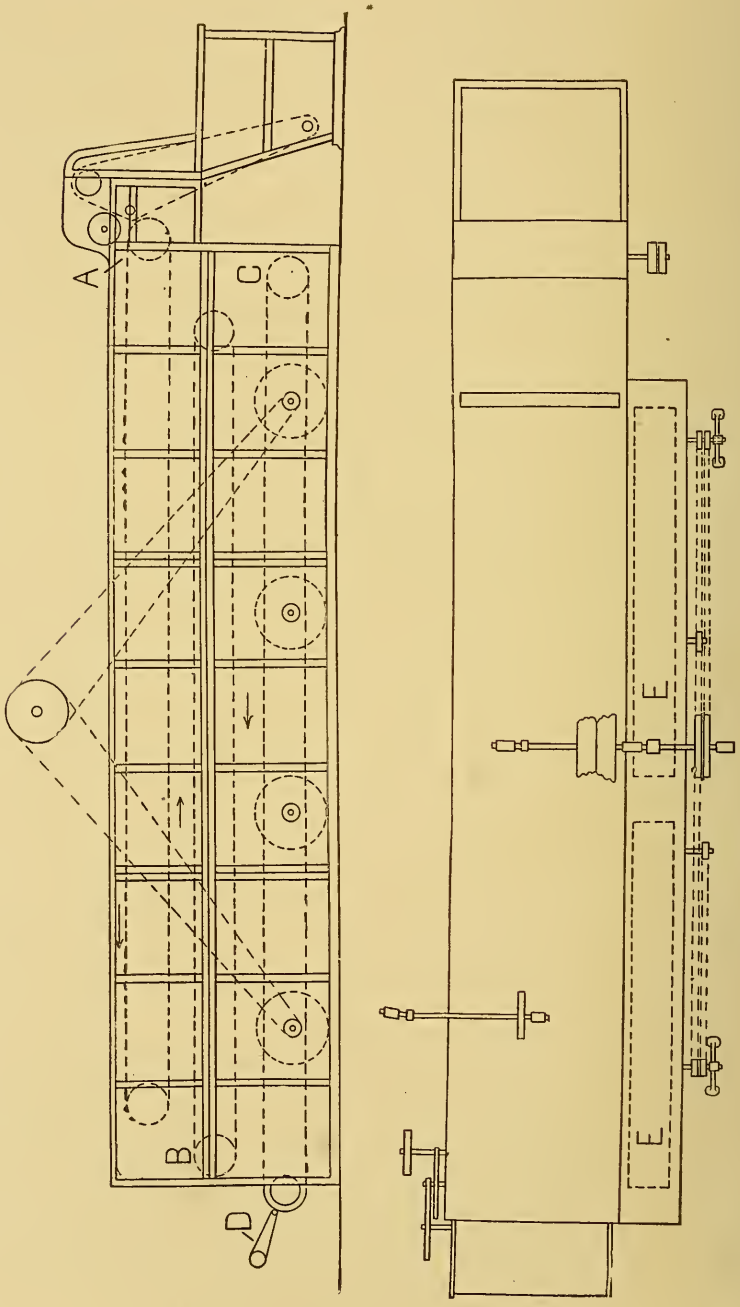


Fig. 39. Plan and Elevation of Three Apron Dryer.

the extra labor required in operating the extractor separately, is generally considered to be more than offset by the automatic arrangement where the wool passes directly from the washer, through the press rolls of the same, and into the automatic feed of the dryer.

This dryer has change gears allowing different speeds for slow or quick drying wools. By arrangement of cone pulleys the automatic feed can be made to admit a thin or thick layer of stock.

Fig. 41 shows another multiple dryer containing five aprons,

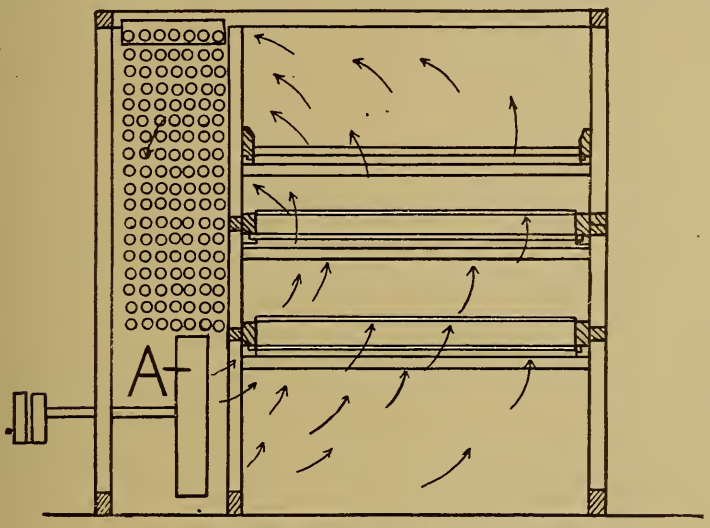


Fig. 40. End View of Three Apron Dryer.

but inasmuch as the arrangement is very similar to that of the three apron dryer, no explanation is necessary.

SHRINKAGE.

One of the most important features in buying wool, and one which is self-evident after it has been cleaned, is the matter of shrinkage. As before shown, all wools are not clean when sheared and after the cleansing process has removed all traces of grease, sand, shives and other extraneous matter, a marked difference is found in the weight of the wool. The difference in weight between unscoured wool and the scoured stock is known

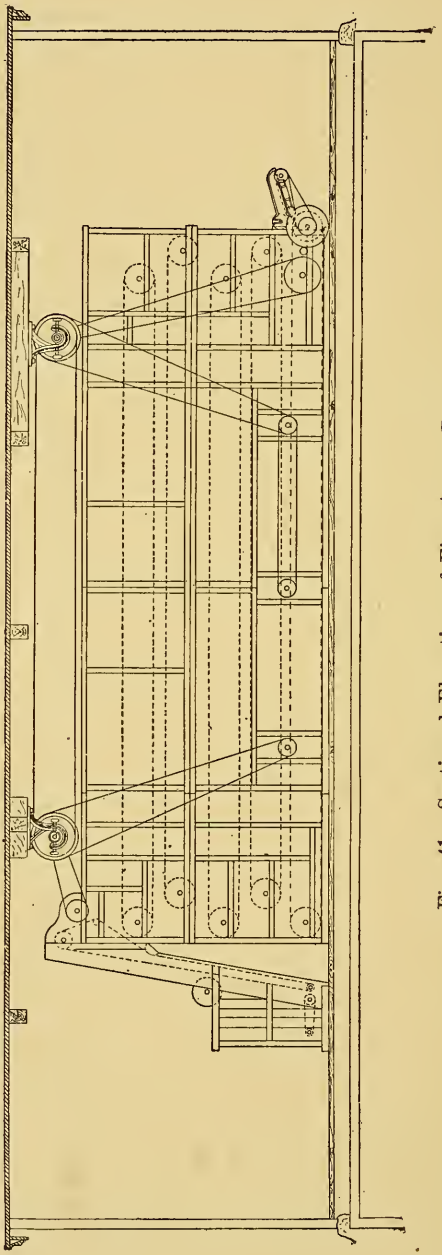


Fig. 41. Sectional Elevation of Five Apron Dryer.

as Shrinkage. Almost all wool buyers are expert in determining by the "Feel" and general appearances of the wool under consideration, the percent of shrinkage within one or two points. This, of course, is the result of years of practice. The shrinkage of a lot of wool under the circumstances is, of course, an important factor in determining its value and price. For example: If a lot of wool costing 25 cents per lb. shrinks 25%, the cost to the buyer on the "clean" basis will be $33\frac{1}{3}$ cents.

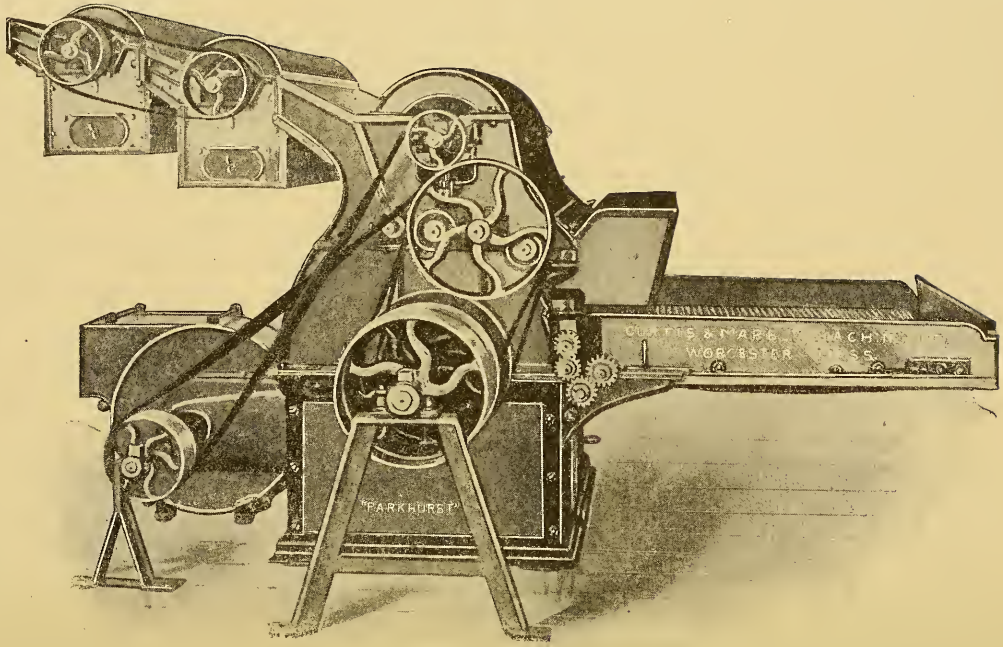
Wool at 25 cents per lb. and 25% shrinkage; consequently $\frac{75}{100}$ of a lb. of scoured stock will cost 25 cents, and 1 lb. on this basis will cost $25 \div \frac{75}{100}$. By cancellation the problem appears as follows:

$$\frac{100 \times 25}{75} = 33\frac{1}{3} \text{ cents per lb.}$$

When the manufacturer of today buys wool for the consumption of his plant, he is generally not only careful in his selection, but has a sample bag sent to the mill for an exact test before clinching his bargain. This sample lot of wool, consisting probably of several hundred lbs., is carefully weighed and carefully scoured and dried by itself; then weighed again. The result is, of course, an exact test and enables him to determine accurately the "clean" price of the entire lot of wool consisting frequently of from 100,000 to 500,000 lbs.

In order that the student may obtain a general idea of wool shrinkages, the following table is appended. This table, in a general way, follows the list of wools which commences on page 7:

NAME.	REMARKS.	APPROXIMATE SHRINKAGE.
Fleeces.	Often spoken of as Washed Fleeces.	About 50 to 52%
Bright Wools.	With the exception of Kentucky.	" 43 " 45%
Territory.		" 65%
Lake & Georgia.		" 40%
Montevideo.		" 55%
Crossbreds.		" 33 to 35%
Cordova.		" 50 %
Alpaca.	Will range from	" 15 to 20%
Irish.		" 20 " 25%
Canadian.		" 18 " 20%
China Wools.	Filling.	" 40 " 45%
Skin Wools.		" 15 " 20%
Khorrassan Spring.		" 30 to 32%
Autumns and Trans Caspians.		" 25%
Aleppo.	Washed.	" 15 to 20%
Owassi.	Washed.	" 25 to 35%
Karradi.	Washed.	" 25 to 30%
Angora Wools.		" 50 to 52%
Scotch Carpet.		" 25 to 35%
Donskoi.	Washed.	" 10 to 12%
China Carpet.	Combing.	" 35%
White Bokhara and White Turkistan.		" 32 to 35%
Mohair.	Turkey.	" 12 to 14%
Mohair.	Domestic.	" 25%
Camel's Hair.	Both Russian and China.	" 30 to 33%.



IMPROVED PARKHURST DOUBLE CLYINDER BURR PICKER, LEFT SIDE

Curtis & Marble Machine Co.

WOOLEN AND WORSTED SPINNING

PART II

CARDING

The wool, after being thoroughly washed and dried, must pass through several preparatory operations before reaching the first breaker card. The number and order of these operations vary according to the class of the wool and the use to which it is to be applied.

Wools will be treated under two general headings as follows:

(*a*) Wools suitable for worsted yarns.

(*b*) Wools suitable for woolen yarns.

These two classes may be subdivided into various grades according to the quality and condition of the wool and the requirements of the fabric for which it is to be used. Long staple wool for worsted yarns does not receive such a large amount of "working" as the shorter wools, for length of staple is of greater importance, in some worsted yarns, than the removal of foreign matter. Short staple wools for woolen yarns may be teased and opened without serious injury, as there is not so much danger of reducing the average length of staple; in fact, there are instances where the presence of excessively long fibers is detrimental to the production of a good quality of yarn.

There are, however, other differences between wool and worsted besides length of staple, which are caused by the action of the machinery peculiar to each process; in fact, it is possible to use one half of a bag of wool for worsted yarn and the other half for woolen yarn. These differences will be brought out and emphasized in their logical order.

Teasing. The condition of the wool after being scoured and dried is such that it ought to be subjected to some process

which will disentangle the staples and thus facilitate the work on the first breaker card.

The illustration shown in Fig. 42 represents the principle on which all machines for this purpose are built. The wool is fed into the machine by a feed sheet and is caught by the teeth on the large cylinder A, which, revolving at a speed of four to five hundred revolutions per minute, carries the wool against the three small "workers" B, which revolve in the opposite direction to the large cylinder, or are stationary. If properly set, the teeth of the large cylinder pass between those of the rolls and thus effectually open the wool.

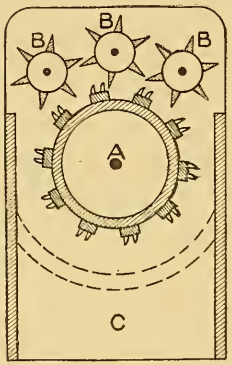


Fig. 42. Sectional View of Teaser.

While this machine should combine the operations of opening the wool and blowing out the foreign matter, in many cases it does not properly do either, as the teeth are set indifferently, and the wool is carried through too easily.

If the rolls B revolve, they should work into each other as well as into the main cylinder, being set so that the teeth will overlap about one inch. The cylinder and rolls are enclosed in a strong sheet metal caae, the mechanism being driven by gears. The broken line represents a grid which assists in cleaning the wool, the dust falling into the compartment underneath.

The above explains the process of opening the wool and while there are many devices for accomplishing the desired end, all rely upon the above principle for their value. It is not often that wools designed for worsted yarns need be passed through an operation of this kind; still there are cases of hard and felted wools which are more or less difficult of separation, which it would not be correct to subject to the process of carding before being opened, as the card clothing would inevitably suffer. Such wools are therefore passed through a machine for the purpose of opening them. When this process is employed on wool for worsted yarns, the speed of the cylinder should be reduced so that the operation will be much gentler on the fibers.

Burring. Some wools contain a large quantity of burrs

which become entangled in the fleece. These burrs cling tenaciously to the wool and as their presence during the carding operation will cause serious waste and rapidly reduce the efficiency of the card clothing, a burr picker is sometimes used to remove them.

The illustration at Fig. 43 represents a typical burr picker. The wool is fed onto a feed apron which carries it forward to the feed rolls, which in turn deliver it to a picking cylinder. The latter, in connection with the burr cylinders, work the wool, the burr being knocked into the burr box by the burr guard. The wool is removed from the burr cylinders by a brush.

For wools containing large quantities of small burrs the chemical process of carbonization is generally used, but for large burrs

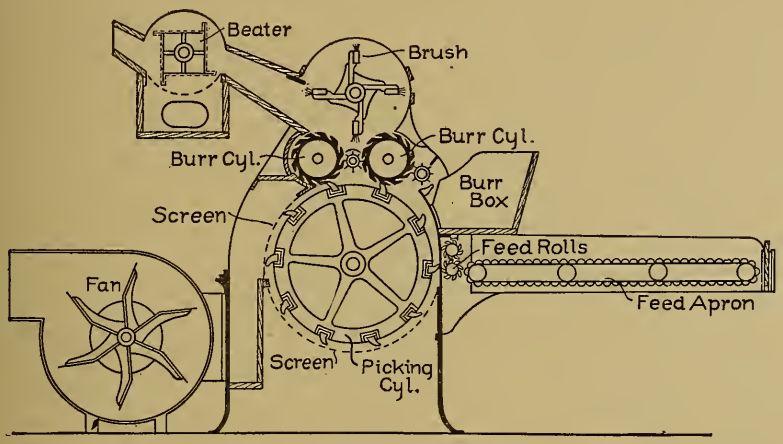


Fig. 43. Sectional View of Burr Picker.

the method of extracting by a burr picker is preferable as it preserves the natural strength and qualities of the fiber.

While many manufacturers claim that the operation of removing the burrs by the picking operation is very destructive to the fiber, it is very probable that the breakage caused by the burr picker would very largely take place on the first breaker cards, so the breakage on the latter is greatly reduced by the action of the burr picker.

Oiling. After wool has been scoured and dried, the fibers lack adhesiveness owing to the natural lubricant of the wool being removed in these processes. Hence, a large quantity of the fibers

would, if not lubricated, make waste or flyings, Oil is applied to the wool to minimize the production of waste and also to soften and impart smoothness to the fibers.

Before the introduction of automatic machines for this purpose, the amount of oil necessary for carding was put on the wool through the simple medium of a garden watering can, with coarse rose or T spout. In some cases the oil was measured but quite as often the amount for any given quantity of wool was guessed. Probably the guessing was almost as efficient as the measuring, for as soon as it was oiled the wool was put into boxes or trucks in which it was taken to the cards. It was quite impossible for

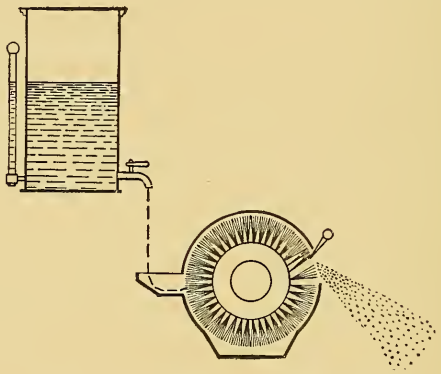


Fig. 44. Rotary Brush Oiling Machine.

the oil to permeate the whole load in the short time before the wool was fed the cards and it may be safely surmised that half the fibers went through the cards without a particle of oil to lubricate them, while many others had so much oil that they would stick together and to the card clothing.

One of the simplest methods in use at present is the rotary brush motion (Fig. 44) in which the circular brush picks up oil from the trough and, as the bristles bend against the knife and spring out straight in passing it, they throw the oil in a fine spray onto the wool.

The oil tank has a guage glass and a regulating valve, so that the amount of oil running into the trough in a given time can be accurately measured and regulated. The oil spray ceases the moment the rolls stop because the brush is driven from the roll shaft.

A connection is also made to the valve of the tank, which automatically stops the flow of oil when the machine is stopped.

If the sight glass is plainly graduated, it is very easy to regulate the amount of oil applied to any pile of wool, and as the oil is always falling in an almost invisible spray, every lock of wool receives its share and goes to the card in the best possible condition.

Different mills have various methods of oiling stock but the above is, in the estimation of the writer, one of the best methods. There are three essential things to be kept in mind and if these are followed carefully the method of application is of little moment.

(*a*) The amount of oil applied must be carefully measured, recorded, and regulated while the machine is running.

(*b*) The oil must be finely divided when applied to the wool.

(*c*) The oil must be applied evenly to every part of the batch.

Any system which fulfills these conditions, and is carefully handled, will produce the best results at the smallest expense.

Mixing. The intermixing of different grades of wool, or of wool and cheaper fibers, such as cotton, mungo, shoddy, etc., is practiced to a great extent in almost every woolen mill in existence, and seems to be increasing rather than diminishing. The principal objects to be obtained in intermixing such materials are the production of special effects and more often a reduction in the cost of the yarn, and, therefore, in the cloth. Perhaps in no instance will the cloth be improved in texture or enhanced in value by the presence of these fibers in the stock previous to the first carding operation. On the contrary, the fabrics are generally low in quality, in consequence of the yarns employed being a composition of remanufactured material and wool.

There are cases, as in the mixture of silk and wool, where the object is to obtain a better thread which will add to the appearance and value of the woven fabric in which it is employed. This, however, is an exception, as generally speaking, the object of mixing is to reduce the cost of the goods. It must not be supposed that the usefulness of mixing is limited to reducing the cost of the yarns, for it is invaluable in producing combinations of several

colors or shades of the same color. It thus affords ample scope for the origination of novelties in the shape of mixture yarns for cheviots and other classes of goods of a similar character.

Such fabrics derive their special features from the nature of the yarns used in their production, and the yarns which owe their characteristics to the mixing process, for the various colors contribute, according to their intensity, to give tone to the spun thread. Therefore, in this preliminary process of cloth designing, there is considerable opportunity for making not only cheap yarn, but at the same time a thread which will be valuable in the production of new styles.

A simple illustration which will clearly show the value of mixing or blending is as follows: Assume that it is required to make three different gray mixture yarns. As black and white, when mixed with each other, produce gray, it will only be necessary to blend, card, and spin varying quantities of black and white wool together according to the tone of the mixture yarn required. Thus, two pounds of black wool mixed with two pounds of white would give a medium gray: while three pounds of black mixed with one pound of white would give very dark gray. If a light gray was required, it could very easily be produced by mixing three pounds of white wool with one pound of black. In practice other colors would be added in small quantities to give a better appearance to the blend.

These illustrations are simply given to show the effect of mixtures. It will be readily seen that there is no limit to the variety of shades which may be obtained by combining several colors in different proportions. The different colors used in preparing a blend may be of different materials or different grades of wool.

As the object of blending is to intermix the several fibers so thoroughly that they cannot be distinguished from each other in the yarn, much care must be taken in preparing the mixture for the machines in which the yarn construction is performed. Mixing does not change the individual characteristics of the fibers, as each retains its own color and properties, yet the amalgamation is so complete that a perfectly uniform mixture is the result.

In preparing the mixing, the component parts must be well

cleaned and opened before entering the mixing room. A common practice is to spread the material on the floor in layers of the various grades. Thus, if the mix consists of different classes of wool of the same shade, a foundation some few inches in thickness is distributed evenly on the floor. A layer of the second grade of stock is then spread over the first layer, and so on. If different colors are being mixed, the process is the same, the thickness of the individual layer varying according to the quantity of each color required to form the proper mixture.

There is a difference of opinion as to whether it is best to oil each layer separately, or to mix the several grades together and oil

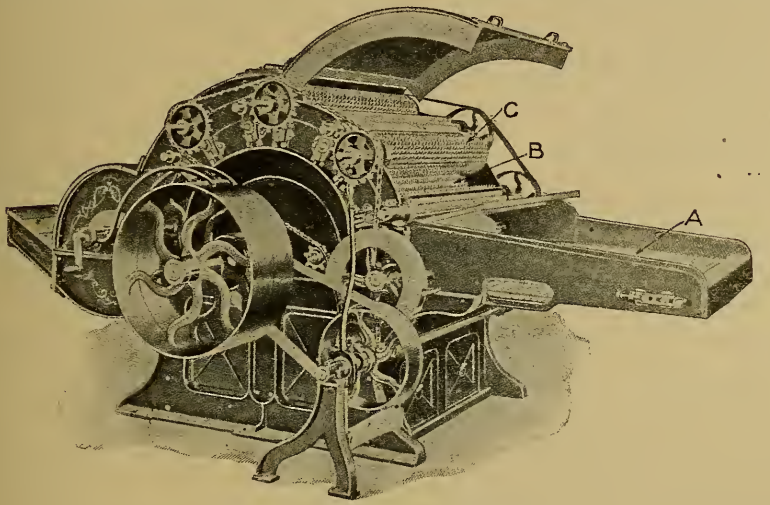


Fig. 45. Fearnought Mixing Picker.

afterwards. This depends a great deal upon the nature of the material being mixed. In some instances one method would be better, and in some cases the other.

In cases where the cotton forms one of the ingredients of the mixture, it is well to prevent oil from getting on this fiber. In such instances, the cotton is first spread on the floor, the other ingredients being spread on the cotton, and oil applied to the top of the bed.

To more perfectly mix the material and thus begin the operation which is finished on the card, the mixture is generally passed through a fearnought or mixer picker, such as is shown at Fig. 45.

Probably the latter name has been applied to this machine on account of the peculiar shape of the teeth inserted in the main cylinder. These teeth are slightly bent in the form of a bow and gradually taper from the base to a point. The main cylinder is about forty-five inches in diameter and makes from one hundred fifty to two hundred revolutions per minute.

The smaller cylinders marked C are called workers and assist in mixing the material. The stock, after having been spread on the feed apron, is passed forward to the main cylinder B by the feed roll when the workers engage the matted locks and thoroughly intermix the fibers. The fan draws the wool from the cylinder and throws it out of the machine. In order to prevent waste caused by loose fibers flying off the cylinder, when in operation, the machine is encased by sheet iron.

WORSTED CARDING

Carding is the first of seven mechanical processes, known collectively as combing, by which raw wool, after it is cleansed of grease and dirt, is converted into tops or balls for the drawing processes. The theoretical uses of carding may be classified under three heads, as follows:

(*a*) Those which are common to both woolen and worsted processes.

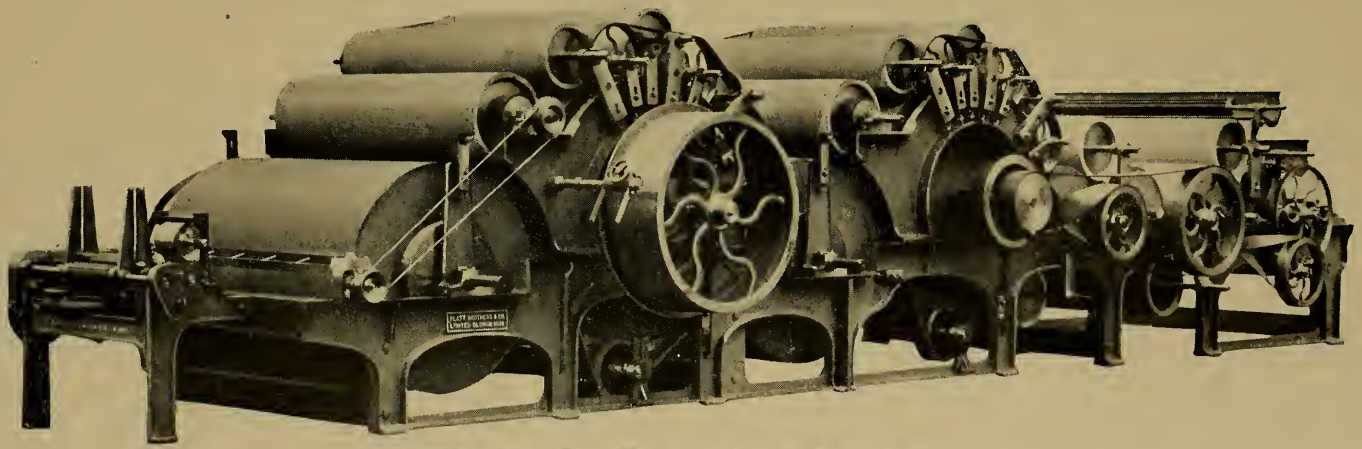
(*b*) Those which are peculiar to worsted carding.

(*c*) Those which are peculiar to woolen carding.

The primary object of all carding is to begin the combing process by separating the fibers one from another; second, to arrange the fibers in a continuous sliver, all parts of which are equal in weight and thickness and so blended that all parts contain fibers of every length and quality; and third, to remove as many knots, seeds and burrs as possible.

In worsted carding the object is, as far as possible, to comb the wool and lay the fibers as straight and as nearly parallel as possible, making a sliver in which every fiber retains the greatest possible length, and in which bulk is of little importance in comparison to length.

In woolen carding the objects are to cross and interlace the separate fibers as much as possible to form a bulky sliver; to blend



DOUBLE WORSTED CARD FOR CARDING MEDIUM WOOLS

Platt Bros. & Co.

fibers of different length and quality; and when blending colors, to mix the fibers so thoroughly that every part of the sliver will be the same shade. For woolen carding long fibers are of no special value and in some cases may be harmful.

The means of obtaining these results may be classified under six different heads, as follows:

(*a*) The direction in which the wire points.

(*b*) The number of wires per inch.

(*c*) The size of the rolls.

(*d*) The relative direction of the surface motion of every pair of rolls which work together.

(*e*) The surface speed of the rolls.

(*f*) The distance of the rolls one from another.

As far as possible these six heads will be treated separately, but as most of them are closely connected with each other, the sequence of the following paragraphs is not entirely in accordance with the above table.

Before considering the intricate arrangement of wires involved in carding, we ought to know what objects are attained by the process in practice, and the essentials of good carded sliver. If a large lot of yarn is to be quite uniform in weight, and even throughout, six things are necessary in the combed sliver, as follows:

(*a*) The sliver must be as near the original length of the wool as possible, and must not contain much short wool or noil knots.

(*b*) The sliver must be uniform in weight; that is to say, ten yards from any one part must weigh exactly the same as ten yards from any other part.

(*c*) Long and short fibers must be blended uniformly, as before explained.

(*d*) There must be no lumps or thick places due to piecings, etc.

(*e*) All fibers must be as nearly parallel as possible.

(*f*) There must be no burrs or vegetable fiber.

Of these heads the carder is responsible for *a*, *b*, *d*, and *f*.

Under the first heading is involved all that is essential in the carding process proper. If the weight of the carded sliver varies

from day to day, it is almost impossible for the comber to make the weight of the comb slivers uniform. To insure the greatest degree of uniformity the wool is put on the feed apron by automatic machines of which the Bramwell of to-day represents the highest type. These feeds are so nearly correct that the output of a card will vary very little in a whole day's work.

It is impossible to overestimate the necessity of care in every detail of the carding process. Attention to size length and grind-

Fig. 46. Enlarged Sectional View of Wool Fiber.

ing of the wire, and care in the adjustment of the various rolls, in relation to one another, for every different class of wool, will repay the time expended upon them, for no staple can go through a card without some of its parts being reduced in length, and if the work be done carelessly the fibers may be so broken that the average length is seriously reduced. Length of staple is all important in worsted spinning, and it is evident that no amount of care in the after processes of combing can remedy the damage.

Theory. The earliest form of carding by hand is a perfect illustration of the theories on which the huge modern worsted cards work and forms a most fitting introduction to this subject Any one can perform the experiment of pulling hairs from his own head and notice in which direction it moves, or which end comes out first when rubbed between the finger and thumb. Theoretically, wool will act in the same manner. Let Fig. 46 represent a single wood fiber, and it is clear that if placed between two plain surfaces having a reciprocating motion, it would always tend to move towards the left, which is the root end of the fiber.

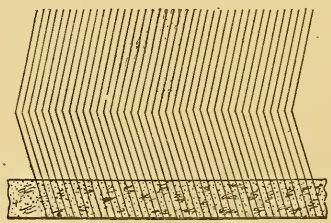


Fig. 47. Card Clothing.

Unfortunately, it is not clear as yet what part this property in wool plays in the carding process, or whether it plays any part at all, for instead of wool being rubbed by plain surfaces it is

treated by an infinite number of fine wires, the points of which are inclined in one direction or the other, and the direction in which these wires are inclined exercises the most powerful influence on the motion of the wool through the machine.

Card Clothing (Fig. 47) consists of leather, or a woven foundation of cotton, covered by a thin layer of vulcanized rubber, and through this foundation the wires are inserted, bent to a uniform angle, and all inclined in one direction. The length of the wire is usually about three eighths of an inch, but the number of points and the thickness or size of the wire vary, in a card for fine wool, from 100 to 500 points per square inch (exclusive of the rolls covered with angular wire).

Fig. 48. Hand Card.

The old hand cards consisted simply of two flat boards eight by five inches, fitted with handles and covered with card clothing as shown in Fig. 48. If a lock of wool were placed between two

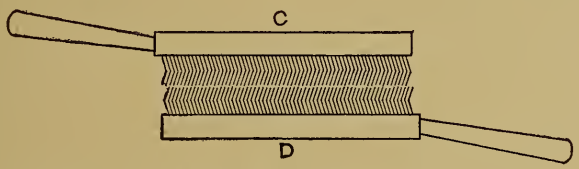


Fig. 49. Hand Cards, Wires Pointing in Opposite Directions.

of these cards as shown in Fig. 49 and they were moved backward and forward parallel to each other, each fiber would be quickly held at some point along its length by one or more wires on one of the cards, and the teeth of the other card must then of necessity be drawn through the loose portions of the staple, separating the different hairs from each other, or combing them in a direction parallel with the line of motion.

If the staple is held by its extreme points, the wires of the other card would comb it from end to end so thoroughly that no after process would be necessary, if the wool could be removed in this straight condition from the card, but, unfortunately, in practice the wool is held at some point between the two ends, and as it hangs in the form of a loop on one of the cards, the teeth of the

other can only comb the two loose ends, and cannot open the middle of the staple until it has been moved from that position.

When the fiber is in this looped condition, there is the greatest danger of breakage, and if two or more staples become felted in washing or from any other cause, there may be two looped ends lying in opposite directions. When the cards move one on the other, the fibers of one staple must give way and be broken. This is only the case when the wires point in opposite directions.

When the wires point in the same direction, as in Fig. 50, the action is entirely different. The motion continues exactly as before, but the wires point in the same direction. If C be moved toward the teeth of D, D will hold all the wool, and the

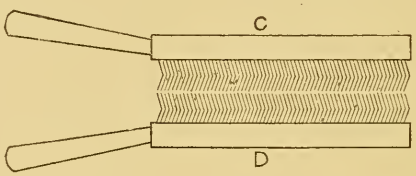


Fig. 50. Hand Cards, Wires Pointing in the Same Direction.

teeth of C will slip easily out of it. As C again comes forward empty, the first rows of teeth will clear nearly all the wool out of D and if a few strokes be repeated, it will empty all the teeth of D and the carded wool will be clear of both.

These two motions of the hand cards illustrate the action of every roll on a modern carding machine (except the fancy which is really a kind of brush), but because the motion of the rolls is continuous and rotary, instead of reciprocating, there are different rolls set apart for each of the two processes affected by the hand cards in their two different positions.

The illustration shown at Fig. 51 has been prepared to show the rolls which perform the operations, formerly done on the old hand cards.

The wool is fed to the large cylinder by R, and is carried to the worker W, which takes the wool from the large cylinder. The small roll marked S strips the wool from W and returns it to the large cylinder to be carried to the next pair of worker and stripper rolls. After passing the last pair of these rolls the wool is raised

on the wires of the large cylinder by the fancy F and is easily removed by the doffer D.

This diagram should be studied carefully, especial attention being given to the direction in which every roll turns, and the direction in which the wire on every roll points.

Every roll of a card which "works" the wool is being continually filled by the cylinder on which it works, and as it would get very much overloaded after its first revolution, a stripping roll is provided to remove the carded wool from the worker. The angle of the clothing of the worker in relation to the wire points of the cylinder is exactly that of two hand cards when in their first posi-

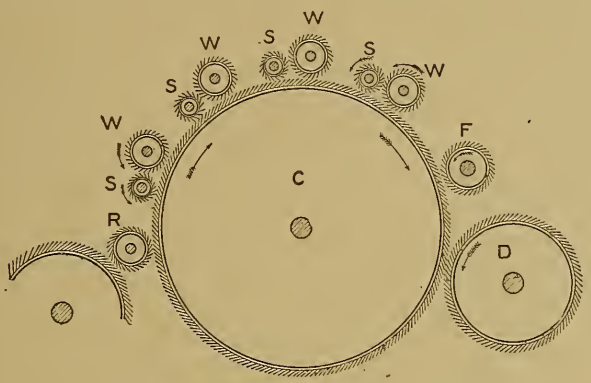


Fig. 51. Diagram Showing Parts of Card.

tion, while the motion of the stripper and the set of its wire makes the action of the stripper and worker exactly like that of the hand cards in the second position, the stripper taking away the carded wool and depositing it again on the cylinder.

There is a hard and fast rule for all stripping rolls, which is as follows: They must move with the point first faster than the roll they clear. In the case of the strippers proper they over-run their workers by thirty times their surface traverse.

The actual direction in which two worker rolls revolve is not essential in the theory of carding; but in order to get any working or combing between two rolls, the wires must be inclined point to point, and one must move points first across the points of the other. That is to say, if two rolls A and B (Fig. 52) were revolving point to point, both making thirty inches surface traverse per

second, they would both be doing exactly the same amount of combing as if the motion of B (Fig. 53) were increased to ninety inches per second, and A were allowed to retreat heel first at its old speed of thirty inches. In both cases the points of B would be running past the points of A at sixty inches per second. It is on this principle that the working power of all rolls must be considered, and in order to get their relative efficiency per inch of width in the machine, the speed must be multiplied by the number of wires per inch linear, counted across the machine. This calculation will show the number of wires moved through any portion of the wool, one inch wide, or the equivalent number of inches which one pin would travel to the same amount of work. Other conditions being equal, the roll which has most points per inch will hold the staples most firmly, and the roll with the fewest points will comb the free ends.

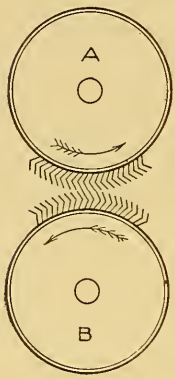


Fig. 52.

Table 1 and Figs. 54 and 55 show the gearing and dimensions of a "fine" worsted card of the type now most generally used. Both cylinders are considered to be running at 100 R. P. M. Any alteration of this speed would alter the speed of every roll in the machine in exactly relative proportion; as every roll is driven from one or the other cylinder.

Wherever the figure 100 occurs first in the calculation in Table 1 the sizes of all gears and pulleys are given in the line of fractions, but in rolls driven from the first licker, $8\frac{1}{3}$ is taken as the unit, and $\frac{2}{9}$, the speed of the feed roll, is the unit for the apron and automatic feed pan. The speeds calculated in Table 1 are used to obtain the results shown in Tables 3 and 4. The clothing for two qualities is shown in Table 2.

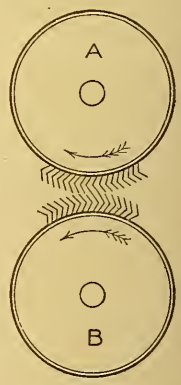


Fig. 53.

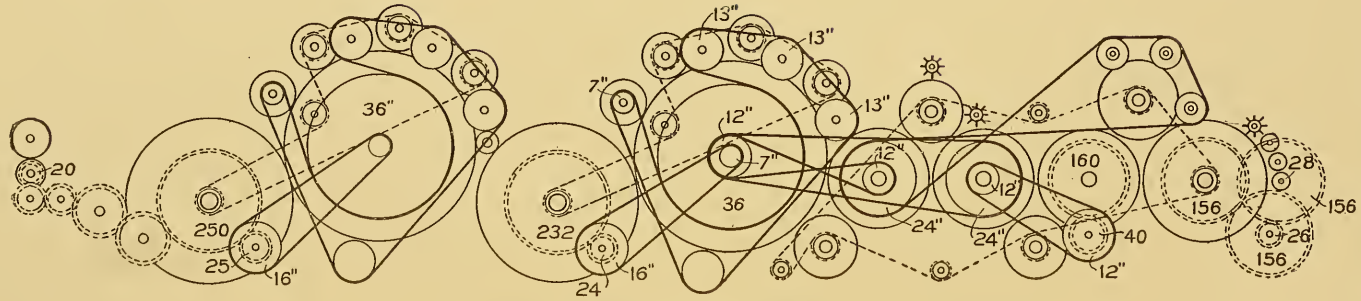
The speeds of a woolen card are given at Table 5 to show the difference in the two systems at equivalent stages in the two processes, and their relative efficiency for producing a sliver in which all the fibers are as nearly as possible of their original length.

TABLE 1

Speeds of a Fine Worsted Card

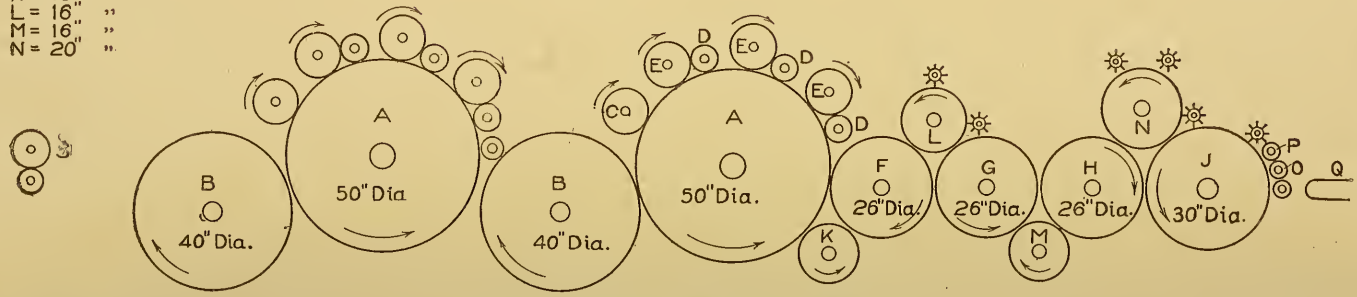
ROLLS	UNIT OF SPEED	GEARS	REV. PER MIN.	INCHES PER MIN.
A. Cylinders	100		100	—
B. Doffers	100	$\times \frac{7 \times 25}{16 \times 250}$	$4\frac{3}{8}$	550
C. Fancys	100	$\times \frac{36}{7}$	$514\frac{2}{7}$	—
D. Strippers	100	$\times \frac{36}{13}$	$276\frac{12}{13}$	—
E. Workers	100	$\times \frac{7 \times 25 \times 10}{16 \times 250 \times 13}$	$3\frac{5}{13}$	—
F. 4th Lickers	100	$\times \frac{12}{12}$	100	—
G. 3rd "	100	$\times \frac{12}{24}$	50	—
H. 2nd "	100	$\times \frac{12 \times 40}{24 \times 160}$	$12\frac{1}{2}$	—
J. 1st "	100	$\times \frac{12 \times 26}{24 \times 156}$	$8\frac{1}{3}$	—
K. 4th Divider	$8\frac{1}{3}$	$\times \frac{6}{12}$	$4\frac{1}{6}$	—
L. 3rd "	$8\frac{1}{3}$	$\times \frac{6}{13}$	$3\frac{11}{13}$	—
M. 2nd "	$8\frac{1}{3}$	$\times \frac{6}{14}$	$3\frac{1}{7}$	—
N. 1st "	$8\frac{1}{3}$	$\times \frac{6}{15}$	$3\frac{1}{3}$	—
O. Feed Roll	$8\frac{1}{3}$	$\times \frac{26}{156} \times \frac{26}{156} \times \frac{25}{28}$	$\frac{2}{9}$	—
P. " " Clearer	$8\frac{1}{3}$	$\times \frac{26}{156} \times \frac{26}{156} \times \frac{74}{28}$	$\frac{6}{5}$	—
Q. Feed Apron	$\frac{2}{9}$	$\times \frac{28 \times 2\frac{1}{4} \times 3\frac{1}{7}}{25} = \frac{44}{25}$	$1\frac{19}{25}$	—
R. Pan of Automatic Feed	$\frac{2}{9}$	$\times \frac{28 \times 11}{25 \times 13} = \frac{616}{2925}$	$\frac{2}{9}$	—
S. Output of Doffing Drawing Off Rolls	100	$\times \frac{7 \times 25 \times 3\frac{1}{2} \times 3\frac{1}{7}}{16 \times 20}$		601

Every one knows that if long and slightly matted hair be combed rapidly with a fine comb, the teeth will catch in the interlacings and tighten them until they become knots, so that a large number of hairs will be broken or pulled out by the roots. But if a very coarse comb is first used and slowly drawn many times through the same head of hair, the fibers will be gradually sep-



Showing Belting, Gearing etc.

C = 12" Dia.
D = 7" "
E = 12" "
K = 16" "
L = 16" "
M = 16" "
N = 20" "



End View of Cylinders and Rolls.

Fig. 54. Diagrams of Worsted Card.

arated until the work may be finished with a fine comb, and a perfect straightening and separating of every fiber from its neighbor

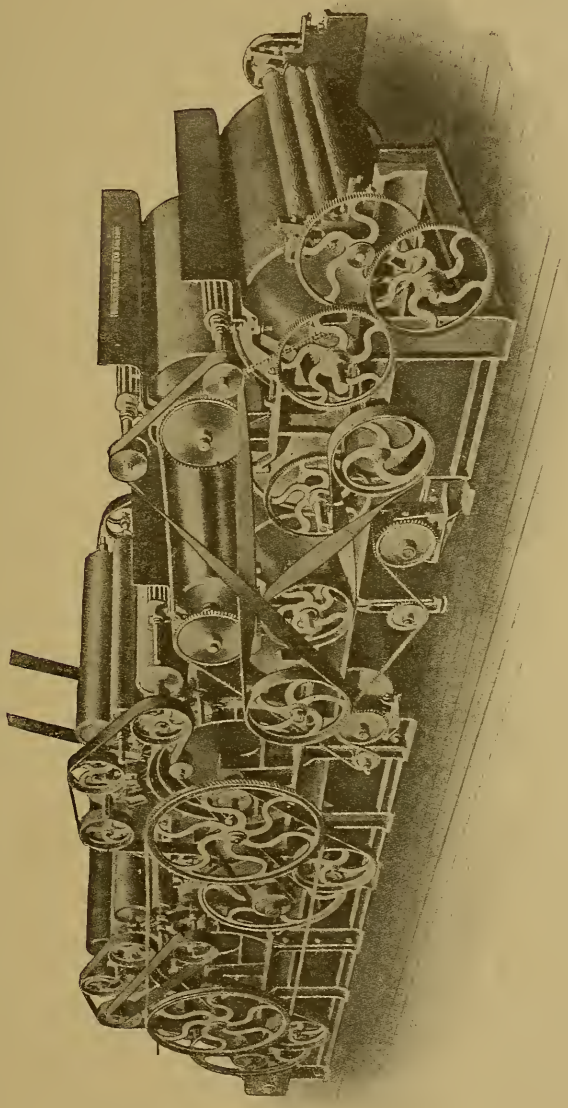


Fig. 55. Worsted Card, Feed End.

will result, with little or no damage to either fibers or locks.

It is exactly in this manner that a worsted card should be

made to treat wool, if the greatest possible length is to be maintained, and it is in the special arrangements to attain this end that a worsted card differs from a woolen card.

The table of speeds shows that the feed rolls move so slowly, in both worsted and woolen cards, that they may be considered as holding the wool stationary, and the teeth are so far apart that they might be almost left out of consideration as an opening process, as they traverse only $\frac{1}{36}$ inches per second and have but six teeth per inch. How widely the woolen and worsted processes differ at all working points except the first will be seen from Tables 3 and 5.

TABLE 2

Card Clothing for Two Qualities of Worsted, all Hardened and Tempered Steel Wire, Vulcanized Fillet

ROLLS	FOR 60's to 70's QUALITY				FOR 48's TO 56's QUALITY		
	DIA.	WIRE	COUNTS	CROWN	WIRE	COUNTS	CROWN
1st Licker	30	18×24	30	6	Garnet	—	—
2nd "	26	29	90	9	24	60	6
3rd "	26	30	100	10	26	80	8
4th "	26	32	115	10	30	100	10
1st Divider	20	25	70	6	24	60	6
2nd "	16	29	90	10	26	80	8
3rd "	16	31	110	10	29	90	9
4th "	16	32	120	10	31	110	10
1st Cylinder	50	34	130	12	31	110	10
1st Workers	12	34	135	12	32	115	10
1st Strippers	7	31	110	10	27	80	8
1st Fancy	12	31	70	8	29	60	7
1st Doffer	40	35	140	12	32	115	10
Angle Stripper	7	31	120	10	30	110	10
2nd Cylinder	50	35	150	$13\frac{1}{3}$	33	125	12
2nd Workers	12	35	150	$13\frac{1}{2}$	34	130	12
2nd Strippers	7	32	115	10	30	90	9
2nd Fancy	12	33	90	8	31	70	7
2nd Doffer	40	36	155	14	34	130	12

Feed rolls 6 pins per inch. Counts and crowns are a method of counting which survives from old hand carding days. Counts are the number of points in 5 inches measuring around a roll, and crown is the number of staples (each having two points) in one inch across the roll. For instance, a cylinder of 130 counts and 12 crown will therefore have 130-5 or 26 points per inch lengthwise, and 12×2 or 24 points crown across the roll. The wire number is the size by wire gauge.

TABLE 3

Worsted Card

ROLLS	SPEED FROM REV. TABLE 1	DIAMETER	INCHES PER SECOND	WIRE	COUNTS	CROWN
1st Licker	$8\frac{1}{3}$	30	13	*18×24	—	—
2nd "	$12\frac{1}{2}$	26	17	24	60	6
3rd "	50	26	68	26	80	8
4th "	100	26	136	30	100	10
1st Divider	$3\frac{1}{3}$	20	$3\frac{1}{2}$	24	60	6
2nd "	$3\frac{4}{7}$	16	3	25	80	8
3rd "	$3\frac{11}{13}$	16	$3\frac{2}{9}$	29	90	9
4th "	$4\frac{1}{6}$	16	$3\frac{1}{2}$	31	110	10
1st Cylinder	100	50	262	31	110	10
1st Workers	$3\frac{5}{13}$	12	$2\frac{1}{7}$	32	115	10
1st Strippers	276	7	101	27	80	8
1st Fancy	514	12	323	29	60	7
1st Doffer	$4\frac{3}{5}$	40	$9\frac{1}{6}$	32	115	10
2nd Cylinder	100	50	262	33	125	12
2nd Workers	$3\frac{5}{13}$	12	$2\frac{1}{7}$	34	130	12
2nd Strippers	276	7	101	30	90	9
2nd Fancy	514	12	323	31	70	7
2nd Doffer	$4\frac{3}{5}$	40	9	34	130	12

* 18 × 24 wire is diamond point.

TABLE 4

Relative Efficiency of Working Points of a Worsted Card

No. of Working Points	Between	Surface Traverse ins. Per Second	Direction of Surface Traverse at Point of Contact	Equivalent of Speed	Points Per In. in One Row	Combing Efficiency
1	1st Licker 1st Divider	13 $13\frac{1}{2}$	Opposite	$16\frac{1}{2}$	12	198
2	2nd Licker 2nd Divider	17 3	"	20	12	240
3	3rd Licker 3rd Divider	68 $3\frac{2}{9}$	"	71	16	1136
4	4th Licker 4th Divider	136 $3\frac{1}{2}$	"	139	20	2780
5 6 7	1st Cylinder 1st Workers	262 2	Same	260	20	5200
	1st Cylinder 1st Doffers	262 9	"	253	20	5060
	2nd Cylinder 2nd Workers	262 2	"	260	24	6240
	2nd Cylinder 2nd Doffer	262 9	"	253	24	6072

If we regard the feed rolls simply as a means of supplying wool at a given rate from the first licker, and leave it out of our calculations as an opening process (because the teeth are so coarse that they only serve to separate staple from staple and not fiber from fiber), we find that there is no work done by any of the rolls of a woolen card (because there is no case of point meeting point) until the unopened staples are rushed by the breast, at a speed of seventy-eight inches per second, onto the wires of the first worker. As the worker retreats three inches per second in the same direction as the breast, there is a working efficiency of seventy-five inches between the two rolls, and if the breast has fourteen pins per linear inch, we may call the combing efficiency of the breast workers as $75 \times 14 = 1050$. The only possible result of such severe treatment is obvious, for it is certain that something must give way. However, the amount of breakage can only be approximately estimated.

TABLE 5

Speeds of Woolen Card

Rolls	Diam.	Speed and Gearing	Rev. Per Min.	In. Per Sec.	Counts and Crowns	Wire
Licker	12	$\frac{100 \times 12 \times 9}{30 \times 12}$	30	19	——	——
Angle	5	——	340	——	——	——
Breast	40	$\frac{100 \times 12}{32}$	$37\frac{1}{2}$	78	$\frac{70}{7}$	26
" Workers	8	See 1st Doffer	$6\frac{3}{8}$	$2\frac{1}{2}$	$\frac{80}{8}$	28
" Strippers	5	$\frac{37\frac{1}{2} \times 32}{10}$	120	31	$\frac{70}{7}$	26
1st Cylinder	50	100	100	262	$\frac{100}{9}$	31
" " Workers	8	See 1st Doffer	$6\frac{3}{8}$	$2\frac{1}{2}$	$\frac{100}{10}$	30
" " Strippers	5	$\frac{100 \times 34}{10}$	340	89	$\frac{80}{8}$	30
" " Fancy	12	$\frac{100 \times 34}{12}$	486	305	$\frac{65}{7}$	30
" " Angle	5	$\frac{100 \times 34}{10}$	340	89	$\frac{80}{8}$	30
" " Strippers	30	$\frac{100 \times 9 \times 25}{18 \times 195}$	$6\frac{3}{8}$	10	$\frac{115}{10}$	33
" " Doffer						
2nd Cylinder	50	100	100	262	$\frac{125}{11}$	35
" " Workers	8	See 1st Workers	$6\frac{3}{8}$	$2\frac{1}{2}$	$\frac{125}{11}$	35
" " Strippers	5	See 1st Stripper	340	89	$\frac{90}{9}$	30
" " Fancy	12	See 1st Fancy	486	305	$\frac{75}{8}$	34
" " Doffer	30	See 1st Doffer	$6\frac{3}{8}$	10	$\frac{130}{11}$	35

Tables 3 and 4 show how much more gently the worsted card begins its work. The efficiency of the first working point is only 198, or one fifth of that of a woolen card breast and worker. The second point is equal to 240 and the third is 1136.

This shows that although in general practice, the speeds are not arranged to give an increase in exact accordance with the rules of either mathematical or simple progression, there is a steady and uniform rate of increase of surface traverse from each working point to the next, until the first cylinder is reached. After that all increase ceases. Just at the point where the wool is so much opened that it would bear more severe combing, the increased fineness of wire and crown in the second cylinder and workers by no means taking the place of a further increase of speed.

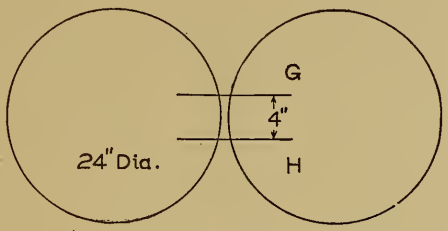


Fig. 56.

Unfortunately, we are confronted with the practical difficulty that the second cylinder is already running at the highest possible speed, without making excessive waste, and we must look for any possible alteration elsewhere.

We do not find that the slow speed of the lickers reduces their carrying capacity in any way, and as theory suggests that there should be a difference between the first and second cylinders, it seems as if No. 1 should be reduced until its surface traverse takes a proper place in the ascending scale shown in Column 5, Table 4, with the clothing so arranged that the combing efficiency of points 5, 6, 7 and 8 will also bear a uniform relation to those coming before and after it in Column 7.

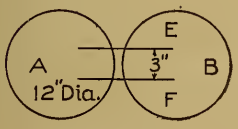


Fig. 57.

The art of carding has not reached perfection, and it is suggested that if improvements are to be effected, those with opportunities for experiment should work along some such lines as are here indicated.

In addition to the relative surface speeds of any two rolls,

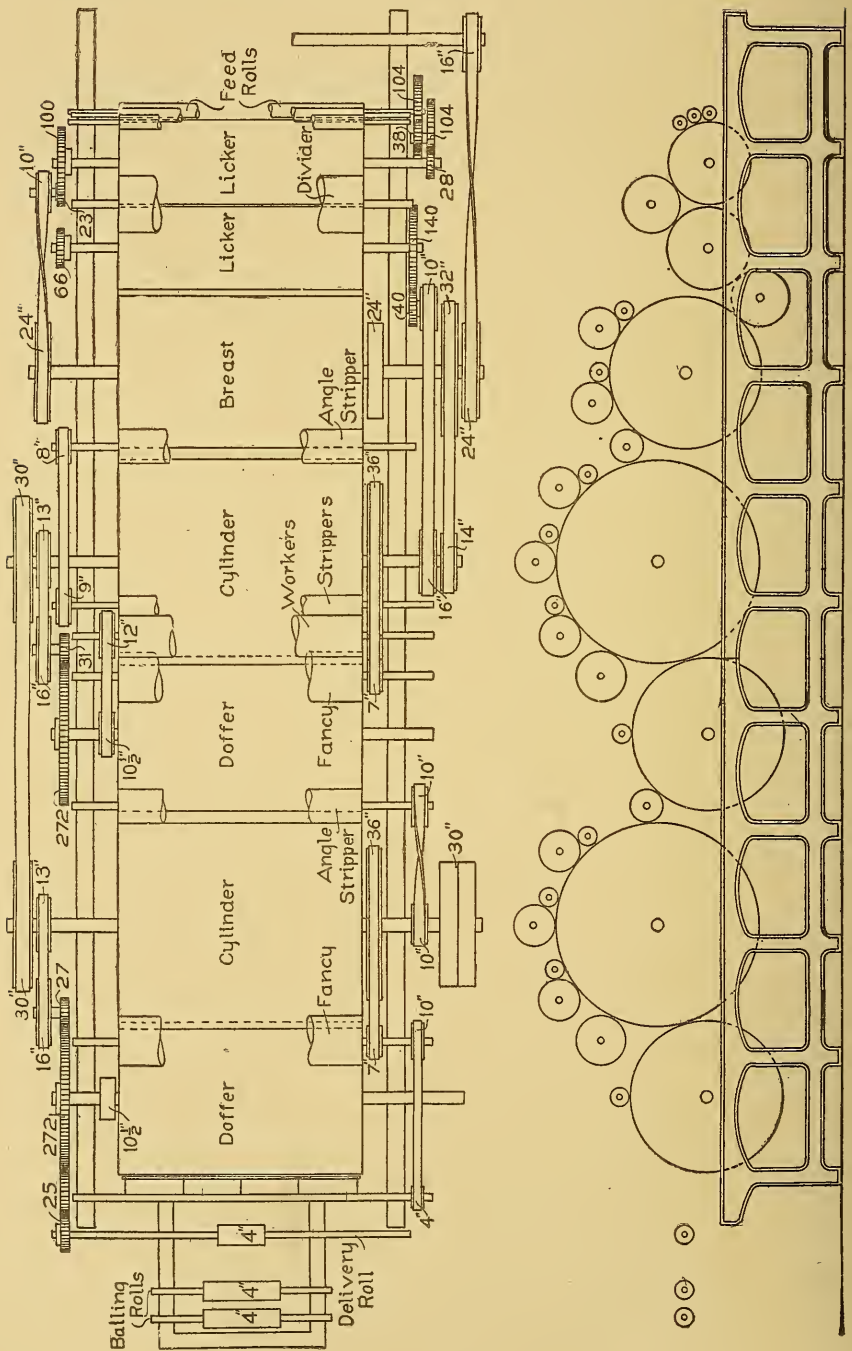


Fig. 58. Diagrams of Two Lickerin Worsted Card.

their size and distance apart directly affect the amount of work they do to the wool. In regard to size, it may be said that the working power of every pair of rolls depends on the time during which they are near enough to do effective work. If we assume that two rolls begin to operate the wool as soon as they come within $\frac{3}{8}$ of an inch of one another, it is clear that they will continue to work for the whole time they are within this distance, and a reference to the figures shows that the surfaces of two 12-inch rolls are within $\frac{3}{8}$ inch of each other for 3 inches, and two 24-inch rolls are within $\frac{3}{8}$ inch of each other for 4 inches (see Fig. 56), and therefore the two 24-inch rolls will do $\frac{8}{6}$ times as much work if the surface speeds and clothing are alike. In the diagram the scale has been exaggerated to show the principle more clearly.

Put in another way, we may say that if a staple were fast on the teeth of B (Fig. 57) at F it will be combed by all the teeth of A between E and F, so that if there are 20 teeth per inch along the circumference it will be combed by 20×3 in one revolution, whereas on G (Fig. 56) it would be combed $20 \times 4 = 80$. It is a case of simple proportion, and one which deserves much greater attention than it receives. It is impossible to say if the working power increases in practice as much as in here shown, for no one could say at what distance the wool begins to be affected by another roll, and if the calculations were based on a distance apart of one half inch instead of one inch the relation of the two calculations would be entirely altered.

For this reason no figures have been entered in any of the tables under this head, but there can be no doubt that larger rolls do more work than smaller ones when other things are equal, and the work done between a 40-inch doffer and a 50-inch cylinder must be severer than that at any other point on a card, even if the action of the fancy (as before described) were left out of account; and if the tests for broken fibers can be taken as a fair average of the breakage which is always going on, some means should be adopted to lessen the great strain on the wool at that point.

Fig. 58 and Table 6 show the particulars of a Davis and Furber breast and two licker-in card for coarse wools. A comparison with Fig. 54 and Tables 1, 2, 3, and 4 will show the difference in the working points between this card and the English style four licker-in card.

TABLE 6

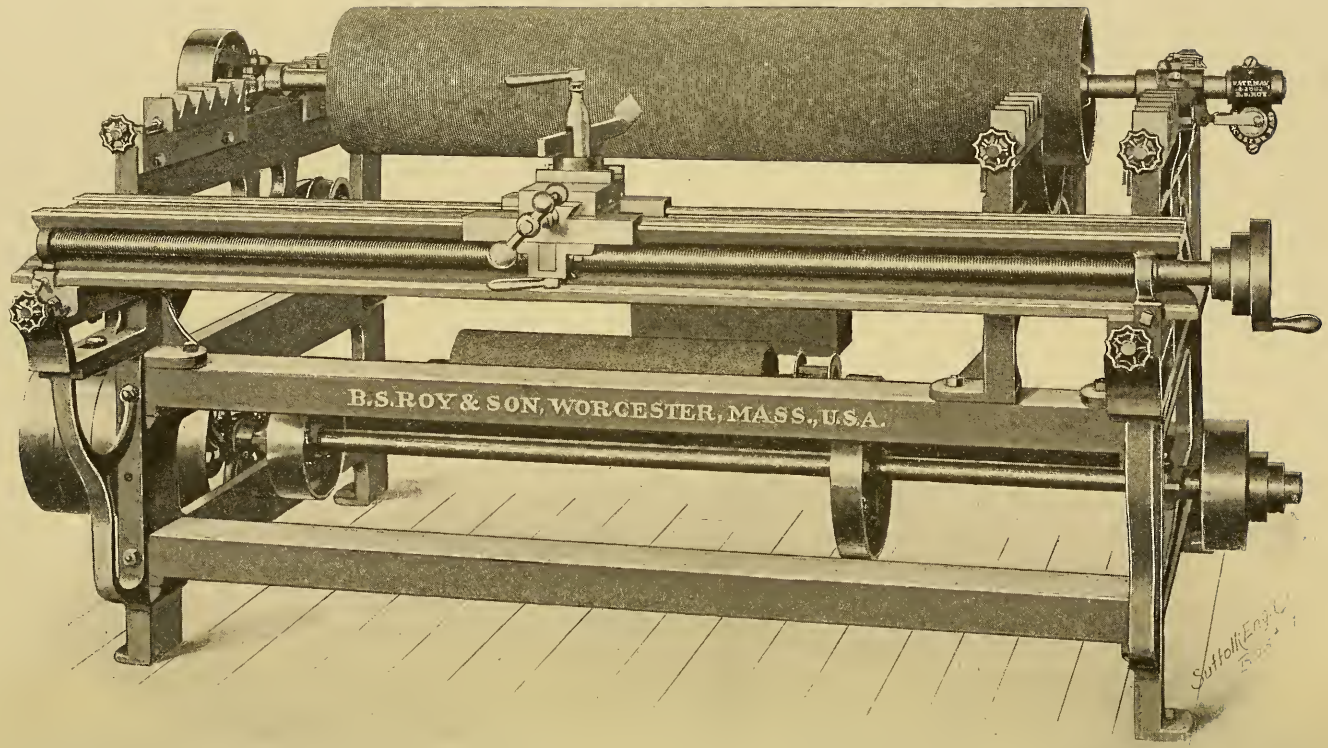
	SIZE WIRE	POINTS PER SQ. FOOT	ENGLISH COUNTS AND CROWNS	DIAMETER	FEET PER MINUTE	REV. PER MINUTE
Feed Rolls	Metallic			3″	1½	2
1st Licker	Burr Wire			20″	110	22
1st Divider	" "			14″	33¼	9.5
2nd Licker	Garnet Wire			20″	210	42
2nd Divider	" "			14″	33¼	9.5
Breast	20 D. P.	8,064	35–4	36″	360	40
Two Workers	22 D. P.	21,736	30–12	10″	21	8.4
Two Strippers	22 Steel	14,400	50–5	4″	80	80
1st Angle Stripper	24	17,280	50–6	8″	628	314
1st Cylinder	33	63,360	110–10	48″	1116	93
Three Workers	34	66,240	115–10	10″	21	8.4
Fancy	26	10,368	30–6	12″	1434	478
Doffer	34	66,240	115–10	36″	87.3	8.6
2nd Angle Stripper	32	57,600	100–10	8″	186	93
2nd Cylinder	35	86,400	125–12	48″	1116	93
Three Workers	36	89,856	130–12	10″	18.5	7.4
Three Strippers	32	46,656	90–9	4″	372	372
Fancy	28	17,280	50–6	12″	1434	478
Doffer	36	89,856	130–12	36″	76.5	7.5

SETTING

The knowledge of how to set a card properly is a qualification of the greatest value, not only in a carding overseer, but to every man who has a card under his care. The best of men make errors, and every overseer should be able to supplement the work of his subordinates. Where rolls are kept in the best possible condition or "point" by frequent grinding, they rapidly alter in diameter, and as every alteration makes it necessary to reset them, it is an art of the greatest delicacy which is needed every day.

In foreign countries much more attention is given to setting, and the gauge is in constant use, whereas, in the United States, the eye and ear are often supposed to be accurate enough for this most delicate operation. The gauge (Fig. 59) very much resembles a closed steel two-foot rule, but instead of having two blades, it has from four to eight, each about $10\frac{1}{2}$ inches long by $1\frac{1}{2}$ inches wide and pivoted at one end, and varying in thickness from $\frac{1}{40}$ to $\frac{1}{80}$ of an inch, or from 22 to 30 wire gauges.

In France, as soon as the machine has been ground and cleaned, and perhaps one or two of the workers replaced by interchangeable duplicates, which are always kept sharp and clean, the overseer literally makes a tour over the card, slipping the selected blade from his set of gauges between every working pair of rolls at two or more points along their breadth. If the gauge fits too tightly, or if there is too much room at either side, a quarter turn



ROY CARD GRINDER

B. T. Roy and Son

is given to the screw which supports the bearings of the worker, to make the adjustment so accurate along the whole working face, that at no point will there be a variation of $\frac{1}{1000}$ of an inch in the space between the points of two rolls.

Setting varies so widely for different qualities of work that it is impossible to formulate any theory, but it is clear that the first rolls must not be so close together as those farther on in the card, and there should be a fairly definite scale of decrease from the beginning to the end. The setting of three workers on each cylinder may be taken as an illustration, for it is far too common to find them all at one distance from the cylinder. If this be the case, the first one will do much more than its share of the work, for its position makes it catch nearly all the projecting fibers and do more than half the work, which ought to be equally divided between the three. This will naturally tend to break many of the fibers, whereas, if each worker were set one or two thousandths of an inch farther from the cylinder than the one behind it, each one of them would be doing the same amount of work and be equally full of wool, if all were clothed alike as is the general practice. If No. 2 were clothed rather more openly than No. 3, and No. 1 clothed more openly than No. 2, the setting would need to be altered slightly in proportion, and the carding would be more gently done in consequence.

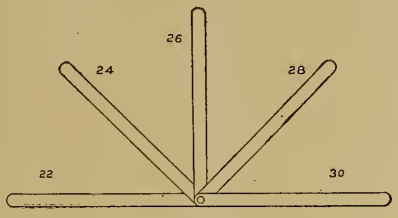


Fig. 59.

In the different machines of a preparing set the draft of the successive machines is a most important item. In a card these various operations are represented by the speed of each successive pair of working rolls, as shown in Table 3; but in the latter the nature of the operation differs widely from the drafting of a preparing box, as the wool is not held firmly at any point in a card after it leaves the feed rolls. It is, therefore, quite impossible to calculate any of the individual drafts, and the total draft has very little relation to the work done, as it really includes numerous doublings as well as drafts, wherever one roll over-runs another, point first; and as these doublings are also impossible to calculate,

the only figure which is of practical value is the draft between the feed rolls and the output of the back doffer This is in inches of surface traverse as $\frac{1}{30}$ to 9, or a total draft of the machine of 270 to 1.

If the slivers are too thick or too small for the comber, they may be changed, either by altering the speed of the back doffer or changing the weight per minute which the automatic feed is delivering on the feed apron.

The former plan is very seldom adopted, although it would have the great advantage of maintaining the total output of the card at its greatest amount. In practice, alteration is generally made at the feed end; the length of sliver turned out remaining constant, and the weight being varied according to size of sliver required.

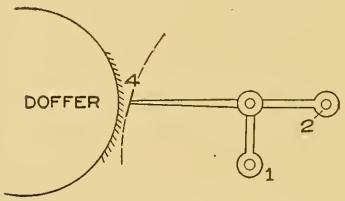


Fig. 60.

Heating. It is a well accepted fact that a good deal of heat is necessary to obtain the most satisfactory results in carding, but it is not very clear what effect the heat has on the structure of the individual fibers, therefore the fact must be taken as it stands, quite apart from any theory on the subject. The most satisfactory results are obtained at an air temperature of over 75° F., but any heat between 75° and 95° F. is good, and if it were not for the discomfort of the operatives it is probable that the temperature of 85° or 90° would be maintained. Sometimes, when the first lickers are made of iron, they are heated by steam; but the more general method is to have three or more coils of steam-pipes under each card, so arranged that the ascending warm air has every opportunity of affecting the wool as it passes through the machine.

DOFFING

The method by which wool is removed from the doffer is so simple that very little explanation is necessary. At the point where the doffer is stripped by the doffing motion the wires are pointing downward, and the doffing comb or plate, which is a smooth steel comb with very short teeth (from 16 to 20 per inch),

rises and falls very fast and as near as possible to the wire of the doffer.

The direction of the points of the doffer and the pull of the drawing off rolls, prevent the wool from rising with the comb on its up stroke, and the doffing comb may be said to simply push the wool down out of the wire, ready to be drawn away by the drawing off rolls. When the wires of the doffer are very sharp and smooth, a free and open sliver of wool will come away from the doffer with very little help from the comb, and in some cases it may be seen to leave the doffer some inches before the comb touches it.

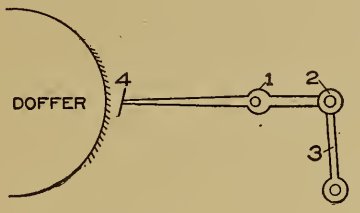


Fig. 61.

The arrangements for driving the comb are so numerous and simple that it will be useless to describe them in detail. They may be all classed under two types as follows: Those in which the comb simply rises and falls $1\frac{1}{2}$ or 2 inches in the arc of a circle (Fig 60), and those in which the comb draws away from the wire at the bottom of the stroke and is farther away from the doffer on the up stroke than on the down stroke. There are many variations of the latter type, but most of them are carried on an eccentric 1, Fig. 61, and have an arm or lever attached by a joint 2 to the shack 3. If the distance from the comb 4 to the center 1 be double the length of the arm 1 to 2 and if the eccentric have a stroke of $\frac{1}{2}$ inch, the comb will have an up and down movement of $1\frac{1}{2}$ inches; and if it be $\frac{1}{16}$ inch from the wire of the doffer on the down stroke (see Fig. 62), it will be $\frac{9}{16}$ away as it rises (Fig. 61). Opinions differ as to which is the better form. The eccentric motion certainly helps to draw the wool away from the wire after it has loosened it, but on the other hand, it travels in a kind of elliptical orbit and

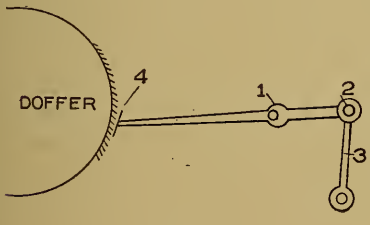


Fig. 62.

is not so close to the doffer for the same proportion of the down stroke as is the comb of the simpler type shown at Fig. 60.

GRINDING

Grinding has three important uses: *first*, to make the wire on the rolls perfectly true—that is to say, that the end of every wire shall be absolutely the same distance from the center of the cylinder; *second*, to keep every wire sharp, so that it will catch the wool fibers readily and easily; and *third*, to keep the points smooth, so that with equal facility the fibers may be again taken from the roll.

The first head raises the much debated question of wood versus metal rolls, and as there are still many who contend that well built wooden rolls can be kept true, and that the clothing has more spring and lasts longer on wood than iron, no hard and fast rule can be laid down. Every one must admit, however, that wood is affected by moisture and heat, and as both these influences are always present when carding is going on, iron and steel rolls have a great advantage in that they have no tendency to alter on account of moisture, and their expansion under different temperatures is so small and uniform in every direction that no possible injury can result. On the other hand, the best of wood with the most scientific preparation will alter under excessive changes of temperature and humidity.

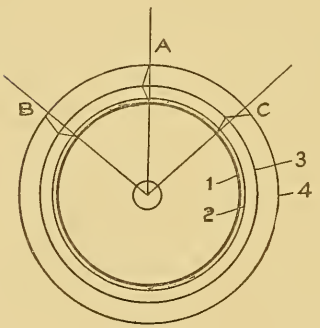


Fig. 63.

The correct angle at which the wires of card clothing should stand is shown in Fig. 63. The inner circle 1 represents the circumference of the cylinder. The space 1–2 is the foundation of the clothing. Line 3 is the correct place for the bend, and line 4 is extremity of the wires after grinding. The wire on the radial line A is the correct position.

When working, the wires have a tendency to bend backwards. They must be so set in the clothing that whichever way they bend, their points must be at the greatest distance from the center of the

roll when in their normal position. This position is on the radial lines. Whichever way A is bent in the foundation, its point comes within the circle 4. C, on the other hand, is very badly set, because when bent back its point would be outside of circle 4 and would touch the roll with which it is working. The wire C would at once lose its point and would damage the wire on the other roll. Wire set like B is very good, but a very slight backward movement would take it so far from the line 4 that it would be of little use in carding.

When a cylinder or doffer is to be clothed, it is first turned up in its own bearings until absolutely true. The clothing is then wound on very lightly, the tension being kept uniform by the use

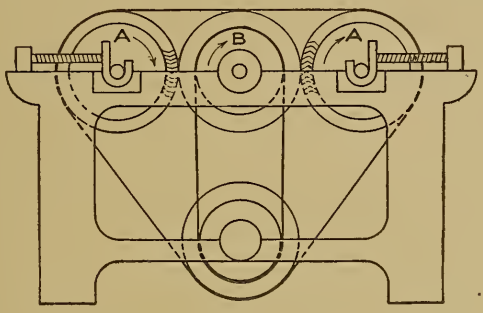


Fig. 64.

of a machine, while the roll is turned away very slowly by means of gearing. In spite of all the care that is taken in the making and the winding on of the clothing, the pitch at which the wire stands is apt to vary slightly in places, or the wire itself may not bed down with equal uniformity all along the surface, so that a roll never runs absolutely true when first clothed. To make it true it must be ground, the longest wires being ground away until they are equal in length to the shortest.

Workers, strippers and fancies are taken to a special frame to be ground (Fig. 64), but a cylinder or doffer is always run in its own bearings, the clothing in every case traveling heel first at a surface speed of 200 or 250 inches per second (100 rev. per min. of a 50-inch cylinder).

At the point of contact, the surface of the emery roll moves in the opposite direction to the cylinder (Fig. 65). An emery roll

about the same size as a worker (12 inches) is put into a pair of worker bearings, which are so adjusted by fine screws, that at first it just touches the highest points of the wire. If this work is not done very gently, the wires will be bent down instead of being ground away to the proper length, and as soon as the roll begins to do its work, running point first, the wires will return to their original position, and make very bad work by taking off the points of other rolls, which they ought just to clear.

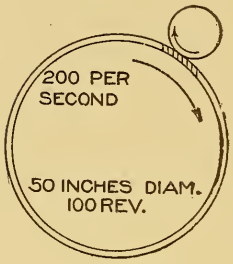


Fig. 65.

As grinding continues, and the longest wires have been somewhat shortened, the emery roll, still revolving, is moved a very little nearer to the cylinder, and in this manner the grinding is continued until all the wires are of uniform length, and the emery roll touches the wire with equal pressure all around.

The method usually adopted is to stop this card every three or four days, and while the cylinders and larger rolls are being ground in their own places, all the workers and smaller rolls are taken to the grinding frame.

The frame is made to take a card roll on either side A of the emery roll B, revolving in the direction shown at Fig. 64, the

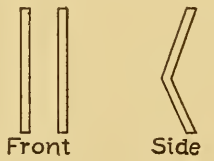


Fig. 66.

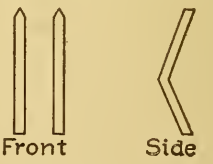


Fig. 67.

workers being driven heel first, with a surface traverse of about 200 inches per second, exactly opposite to that of the emery roll at the point of contact.

If the emery used on the roll be very fine in grain, the resulting point on the wire would be quite square when seen from back or front, with a diamond or tool point when viewed from a side elevation. This is shown at Fig. 66. In practice this is not very satisfactory, for when any piece of metal is filed or ground squarely across the grain, a slight lip or curl at the edge almost invariably

occurs, and although it is so small as to be quite invisible on the wire, it is sufficient to affect the fine fibers in carding and cause them to stick instead of leaving the roll freely.

Some method had to be devised to remove this rough edge, and it was found that fine emery laid on the roll in grooves, or the use of very coarse grained emery, had the same effect as a file held diagonally, the wire being ground to a knife edge instead of a square point, and having the same tool point when seen from the side. This greatly magnified the surface of the roll, the points of the wires would appear as in Fig. 67, and, furthermore, they would be without rough edges.

AUTOMATIC FEEDING

The object of an automatic feed is to ensure that every yard of sliver shall be exactly the same weight as every other yard, in other words, that the sliver shall always be exactly the same thickness. When wool was fed by hand on to the feed sheet, it naturally followed that the weight of the sliver varied from time to time, because it was impossible for any feeder, however expert, to judge by feel or by any other method, if there be just the right weight of wool on the feed sheet.

Carders who were particular began to consider ways and means to get the weight of their sliver more constant, and some of them marked the lattice into divisions, each say twelve inches long. A scale to weigh the wool was placed by each feed sheet, and just as one mark was passing the feed rolls, half a pound or so of wool was taken from the scale and spread over a division of the feed sheet. This system is only accurate where the greatest care is used, but it introduced the principle on which the automatic feeds are constructed. The latter weigh out a given weight of wool on to a given length of feed sheet, and are so arranged that the weight can easily be altered as required for different qualities of wool. It follows that, to do work of this kind, the mechanism should be very delicate.

The feed roll moves $\frac{2}{9}$ of a revolution per minute, as shown in Table 1, and is geared to the feed sheet by two gears of 25 and 28 teeth. The feed sheet moves $\frac{2}{9} \times \frac{28}{25} \times 2\frac{1}{4} \times \frac{22}{7} = \frac{2}{5}$ inches per minute. But the cam C (Fig. 68) which opens the pan P by means

of lever L, is also driven direct from the feed roll, through the same gears, 25 and 28, and a chain over two sprocket wheels of 11 and 13 teeth. The two gears which drive the cam C are equal in size, $\frac{2}{9} \times \frac{28}{56} \times \frac{11}{13} = \frac{2}{9}$. This shows that the pan opens once every $4\frac{1}{2}$ minutes, that is $\frac{9}{5} \times \frac{9}{2}$ or once every time the feed sheet has moved

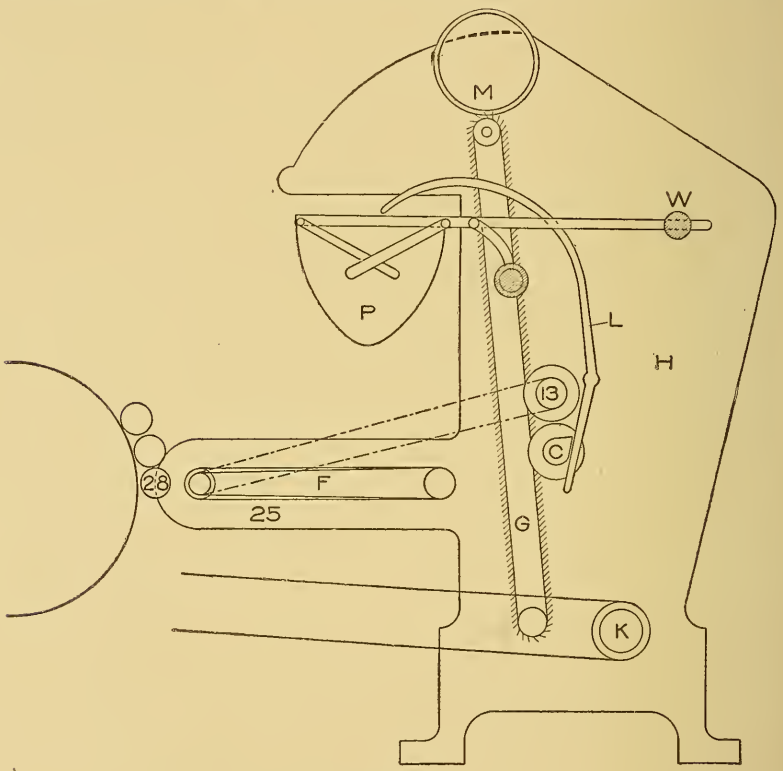


Fig. 68.

$8\frac{1}{10}$ inches, and if the pan always contains one-half pound of wool, it follows that every $8\frac{1}{10}$ inches of feed sheet must always be covered by one-half pound of wool. In this, the whole principle of the machine is embodied.

The mechanism for filling the pan is quite simple. The sheet G is covered with pins, and when the machine is running, they carry the wool up from the hopper H over into the pan. The sheet is started by the lever L as soon as the pan closes at every revolution, and the sheet continues to run until there is wool

enough in the pan to operate the mechanism for stopping the feed sheet. The other movements on the machine are simply arranged to distribute the wool evenly in the pan, which extends the full width of the machine, and to press the wool up to its proper place after it has fallen on to the feed sheet. In Fig. 68 the belt from K to M, and the clutch gear which drives the sheet from M are not shown.

BURRING

There are few things which cause more annoyance to carders and spinners than the seeds of a plant, native to Australia, which are known to every one in the trade as "burrs." Their natural shape, as seen in the unwashed fleece, is that of a small pea, but they are soft, and are built in spirals of prickly fibers, which are capable of unwinding to such an extent that after carding, each burr seed may produce several inches of thin spiked fibers which are so injurious both in spinning and weaving. When the seeds are ripe they stick to the wool of any sheep passing the plants on which they grow; and they adhere through every process until they are forcibly removed or destroyed.

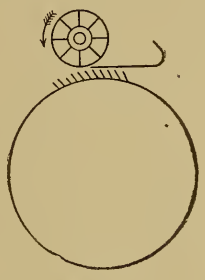


Fig. 69.

Burrs now occur in small numbers in almost every class of wool, so that all carding machines are supplied with rolls for removing them. Any number of burr rolls up to six are placed above the lickers and dividers, so that the burrs may be knocked out before they are opened by the carding process. Each roll is set as shown in Fig. 69, with its blades always revolving against the points of the card wire.

In this position the draught caused by the revolution of the beater, drives the wool on to the wire, while the burrs are hit by the blades of the beater and thrown forcibly into the pans provided for them. If the burr roll revolved in the opposite direction, it would tend to lift the wool as well as the burrs from the card. With wool which contains only a medium quantity of burrs, this process is very efficient; but in cases where it is not essential to have every particle of burr fiber removed, or where the burrs are very numerous, other methods are adopted.

The oldest machine for this purpose consisted of two heavy iron rolls, turned up very true and fixed so rigidly in a frame that they were always about one hundredth of an inch apart. Through this very small space they could go with impunity, but any burr was crushed to pieces in passing. When such rolls are used before carding, the locks of wool are apt to go through in lumps so large that they, like the burrs, are cut to pieces, and to insure the wool passing through the rolls in a uniformly thin film, the rolls have been used in the middle of the carding process and sometimes later than that.

Probably when placed in the middle they do their work best, for the rolls which precede them open out the staples into a film of uniform density, so that nothing but the burrs can be crushed. Most of the broken fragments fall on the floor as the wool passes over the remaining rolls. Any pieces which can be found in the carded sliver after this process are very short, and can always be taken out in the combing.

The latest invention for removing burrs consists of a roll covered with square-toothed garnet wire, so finely set that at first sight the roll seems to be solid. The fact is that the wires are set so close to each other that the wool can just get down between them, but the burrs cannot do so. This roll is usually placed as early in the card as possible. Wherever it is placed, a burr roll is always placed above it, the blades coming within $\frac{1}{50}$ of an inch of the wire, so that they can scrape away every burr, while the wool held fast between the wires is dragged away from the burrs to the carding rolls which follow.

Another system of removing burrs is the carbonizing process, which is very frequently used in the woolen trade, and doubtless a great deal of wool which is used for worsteds is carbonized before it goes to the comber.

The best carbonized wool is that which is treated before it is removed from the skins, but mostly it is treated after scouring; it is, in fact, necessary that all impurities should first be removed. The wool is then put into a solution of sulphuric acid in clean water (of a varying strength from 6° to 10° Baumé) for 20 to 30 minutes, when it is taken out and put into an extractor to remove every trace of moisture. When dry, the wool is placed in an oven

or dryer at 45° C. until quite dry, when the temperature may be raised to 100° C. until all vegetable matter is thoroughly disintegrated. After this treatment all that remains of the burrs and shives will fall out in the carding.

The only disadvantage of this process is the effect of the acid on the wool. Theoretically, it does no harm if the acid never exceeds 12° Baumé in density, but where wool has to be spun to fine counts, it is found that either the acid or the baking, or both, affects the spinning power, in addition to making the wool much harsher to the "feel."

WOOLEN CARDING

The usual method in carding for woolen yarns is to employ three machines; *i. e.*, the First Breaker Card, Second Breaker Card, and Finisher Card with Condenser. The principles employed in woolen carding are the same as those used in carding for worsted yarns as explained at Fig. 51; yet there are many differences between the two processes, as will become apparent by studying the following explanations.

It will be well to have firmly fixed in the mind the difference in speeds of equivalent parts in the two processes which may be noted by reference to the tables.

Up to and including the first breaker of a set of woolen cards, the principles of worsted carding and woolen carding are identical, with the exception that in a worsted card the wool is drawn straight from the center of the doffer, in order to keep the fibers straight, while on the first breaker of a woolen set it is drawn from the side, which causes the wool delivered from the doffer to roll up into a round sliver, with the fibers intermixed in every direction.

FIRST BREAKER CARD

The illustration shown at Fig. 70 represents a Davis and Furber first breaker card, equipped with Bramwell feed and Torrance balling machine, which may be taken as a representative machine. The main cylinder A is forty-eight inches in diameter; doffer B, thirty inches; fancy C, ten inches. Each of the six workers D, are seven inches in diameter; the strippers E are three inches; the tumbler F, nine inches; burr cylinder G, seven inches; and the feed rolls H, two inches.

The purpose of this machine, as implied by the name, is to break up the raw stock, thoroughly intermix the fibers, and deliver the wool in a free and open condition to the second breaker.

It is more important in the woolen carding process that the feed and the delivery should be absolutely even, as there are no opportunities to correct unevenness or imperfections such as there are in the processes of worsted manufacturing. For this reason it is essential to have every part working correctly.

In starting the first breaker it is best to weigh enough wool in the feed pan to make a good compact feed on the feed apron. If the drawing is too heavy or too light it must be regulated to keep the second breaker card well supplied. Due consideration must be given to the weight of roving to be made on the finisher and condenser. If the sliver from the first breaker is too heavy the second breaker and perhaps the finisher will be compelled to do more work than they should do, which will cause imperfect roving and generally unsatisfactory results.

Table 7 gives all the particulars of the first breaker card.

TABLE 7

FIRST BREAKER CARD

Name	Dia. (bare)	Dia. (clothed)	Revs. per m.	Surface speed clothed	Wire	Size of wire	Counts	Crowns	Written
Feed rolls	2″	2½″	Change	Change	Lickerin 4 per in.	No. 1			
Burr guard	2¾″	3½″	525	481.2					
Burr cylinder	7″	7¼″	112.5	213.5	Burr long top 10 per in. Steel	" 2			
Tumbler	9″	9¾″	138.5	353.6	Twilled Steel	" 32	85	10	$\frac{85}{10}$
Workers	7″	7¾″	4	8.12	Twilled Steel	" 32	85	10	$\frac{85}{10}$
Strippers	3″	3¾″	350	343.7	Twilled Steel	" 32	85	10	$\frac{85}{10}$
Main cylinder	48″	48¾″	90	1149	Twilled Steel	" 32	105	8	$\frac{105}{8}$
Fancy	10″	11¼″	525	1615	Twilled Steel	" 32	60	8	$\frac{60}{8}$
Doffer	30″	30¾″	7.2	57.9	Twilled Steel	" 32	70	12	$\frac{70}{12}$

Feed Rolls. To commence at the beginning of the machine the feed rolls are either metallic or leather covered. If covered with leather the wire should be convex, and should be set as close

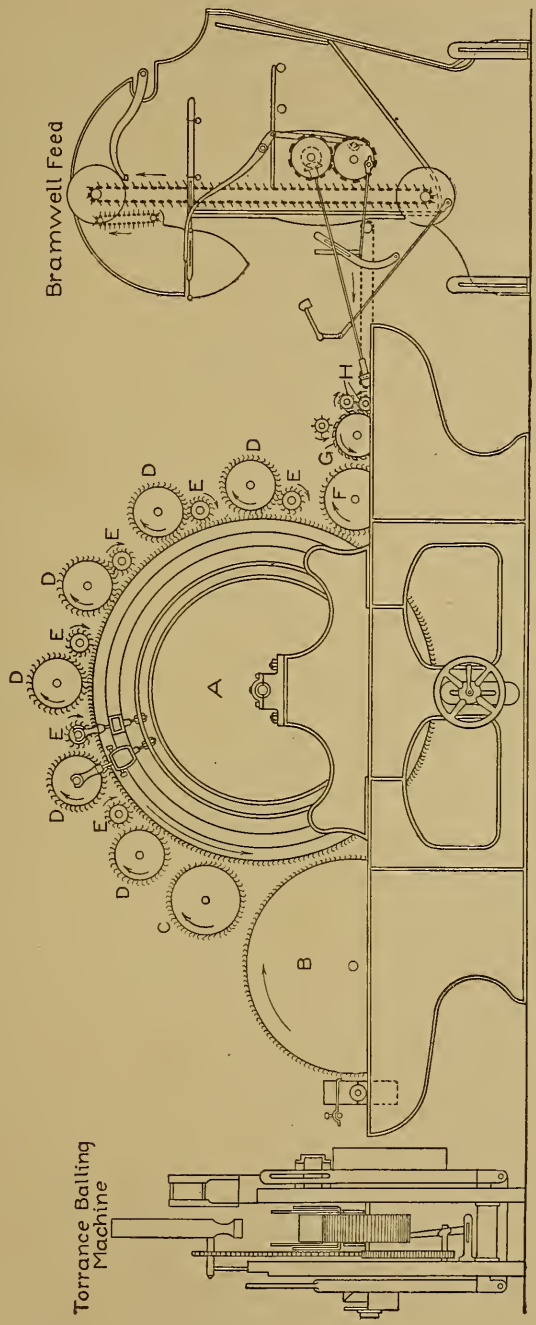


Fig. 70. First Breaker Card with Bramwell Feed and Torrance Balling Machine.

as possible. If metallic, it is best to have the points intersect as they will hold the stock much better. These rolls take the stock from the feed apron and deliver it to the burr cylinder 4.

Wipe Roll. The wipe roll, as shown at 3 in Fig. 71, should be set close to the top feed roll. Its purpose is to brush back any stock that is carried up to it on the top feed roll.

Burr Cylinder. The burr cylinder, shown at 4 in Fig. 71, should be metallic covered. It is absolutely necessary to keep this cylinder sharp as its office is to take the stock from the feed rolls and deliver it to the tumbler.

Burr Guard. The burr guard, shown at 5 in Fig. 71, should be set close enough to the burr cylinder to knock off the burrs.

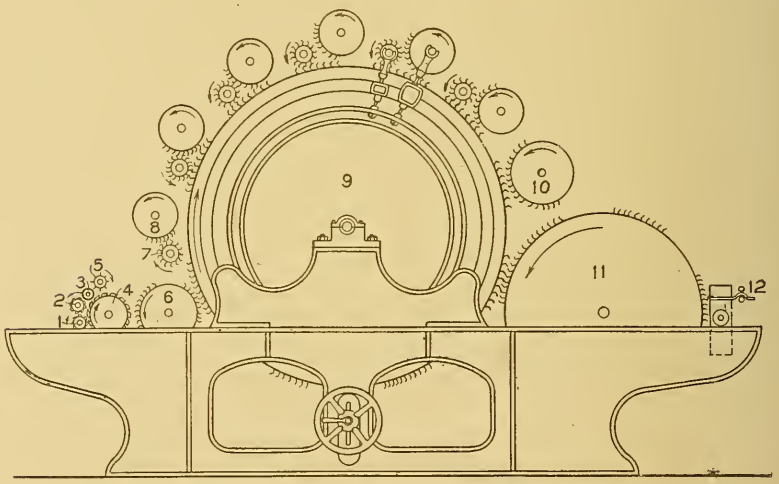


Fig. 71. Side Elevation of First Breaker Card.

It should revolve against the points of the wire on the burr cylinder. If the burr guard revolved in the opposite direction it would have a tendency to raise the wool out of the wire, while by revolving against the points of the wire on the cylinder, the draught caused by its beaters or wings drives the wool into the wire while the burrs are hit by the beaters and knocked into the pan provided for them.

Tumbler. The tumbler, shown at 6 in Fig. 71, should be fillet covered with No. 32 round or double convex wire. It is very essential that the tumbler be kept sharp and true in order to prevent

the stock from dropping, and to ensure that it is delivered evenly to the main cylinder.

Main Cylinder. The main cylinder, shown at 9 in Fig. 71, takes the wool from the tumbler and carries it forward to the first

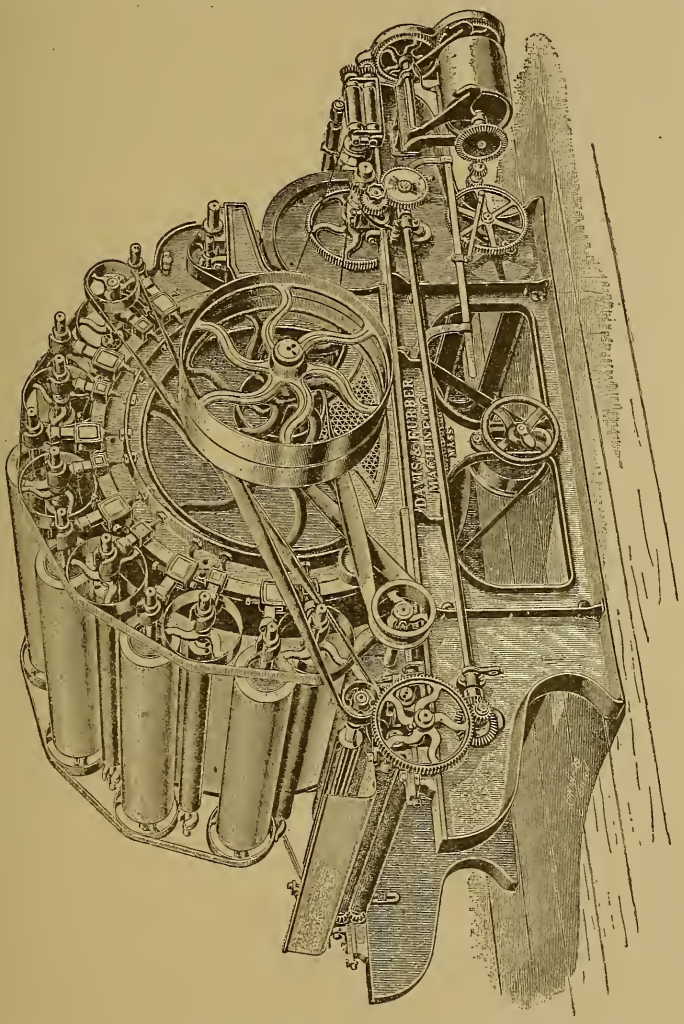


Fig. 72. First Breaker Card.

worker 8 which is rapidly filled with wool and as rapidly stripped by the stripper roll 7 The stripper should be set so close to the worker that the sound of the friction caused by the passing of the wires may be heard by listening attentively. The points of the

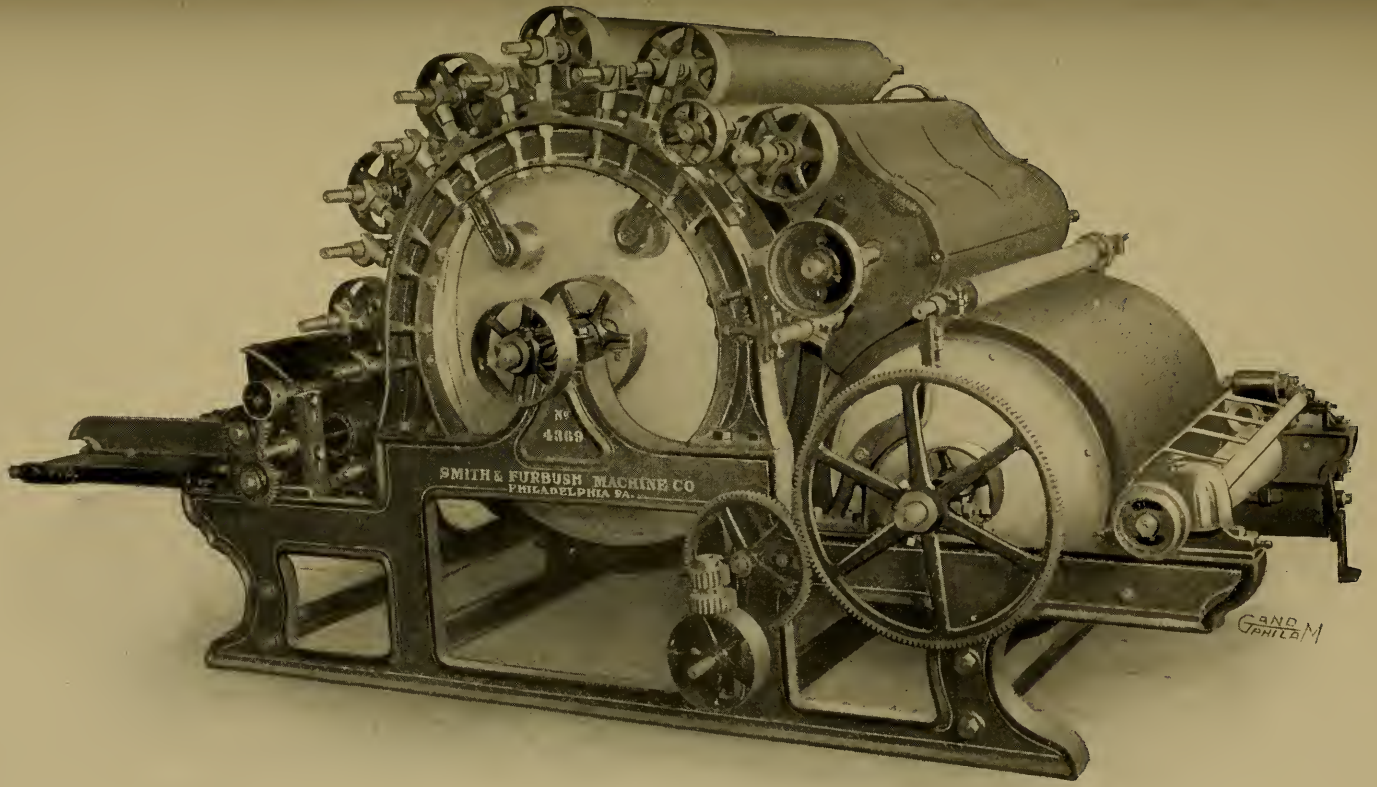
wires on the stripper revolve against the back of the wires of the worker which, combined with the great difference in their speeds, causes the stripper to remove or strip the wool from the teeth of the worker. Refer to Fig. 71 and note carefully the direction in which the rolls revolve, as indicated by the arrows.

As explained in the process of worsted carding, when the wires or teeth meet, point to point, the cards in so meeting card the wool and fill each other with carded wool, but when the points on one roll or cylinder rub against the back of the wire on another, the one running point first strips the one it is running against, provided it is at a greater speed. In this instance the stripper runs point first against the back of the wires on the worker and as it runs at a speed of ninety inches per second while the worker runs only two and one-half inches per second, it strips the wool from the worker very effectively.

Thus, it will be understood that as each worker is being continually filled with wool on one side by the main cylinder, it is just as continually being stripped on the other side by the stripper. The wool is delivered back to the main cylinder by the stripper and is carried back to the next pair of workers and stripper rolls. Each set of workers and strippers repeat the operation performed by the first pair, the wool being carried forward to the fancy.

The action of the pairs of rolls through which the wool has passed has opened and carded the stock, and now it is necessary to prepare for the removal of the wool, or what is technically known as *doffing*. The fancy, shown at 10 in Fig. 71, raises the wool on the teeth of the main cylinder preparatory to doffing. To thoroughly understand how this is brought about, careful reference must be made to Fig. 71. Note the direction in which the wires point and compare this to the position of the wires in the main cylinder; also note the direction in which the fancy revolves.

The surface speed of the fancy must be greater than the surface speed of the cylinder (see Table 7), or it could not possibly raise the fibers; yet the difference in speeds must not be too great or the wool will be thrown off the cylinder. The fancy revolves with the back of the wires toward the cylinder so the relative position of the wires on the cylinder and fancy is back to back, no points being presented direct to either. The result of this is that



FURBUSH FIRST BREAKER CARD
Smith & Furbush Machine Co.

the fancy acts simply as a brush to raise the wool out of the cylinder. The speed must be regulated so nicely that the wool will just be raised to the surface of the cylinder wire so that it may be easily removed by the doffer.

Doffer. The doffer, shown at 11 in Fig. 71, presents the points of the teeth to the points of the cylinder and removes the wool (which has been raised by the fancy) from the cylinder, carrying it around to the steel doffer comb 12.

Doffer Comb. The Doffer Comb has a reciprocating movement, and strips the wool from the doffer, delivering it to a ball (if side drawing) or to the feed apron of the Apperly feed if this system is used. The explanation of this system is reserved for another chapter.

The Davis and Furber first breaker card is furnished with a side drawing balling head as some manufacturers still prefer the use of this method with a simple creel behind the second breaker, but this balling arrangement is not attached when the Torrance balling machine, shown at Fig. 70, is used, a pair of delivery rolls being substituted.

Torrance Balling Machine and Creel. This machine is for the purpose of winding the side drawing from the first breaker into flat "balls" which are then placed in a creel and fed to the second breaker. The advantages claimed for this machine are that the shape of balls is such that a larger number of ends can be fed to the second breaker without using an exceptionally large creel. It will be readily understood that the larger the number of ends fed to the second breaker, the more even will the sliver be, and consequently the roving from the finisher will be more even and the wool will be more thoroughly blended.

SECOND BREAKER CARD

The second breaker is an almost exact duplicate of the first breaker, the chief difference being that the burr cylinder is replaced by a lickerin which is covered with a coarse card clothing in place of burr wire. The reason for this is that the wool is opened on the first breaker and is in a comparatively clean condition, which makes the use of such strong teeth as are used on the burr

cylinder, unnecessary. Over the lickerin is placed a lickerin fancy which cleans the lickerin.

Reference to Fig. 73 will show the similarity of this machine

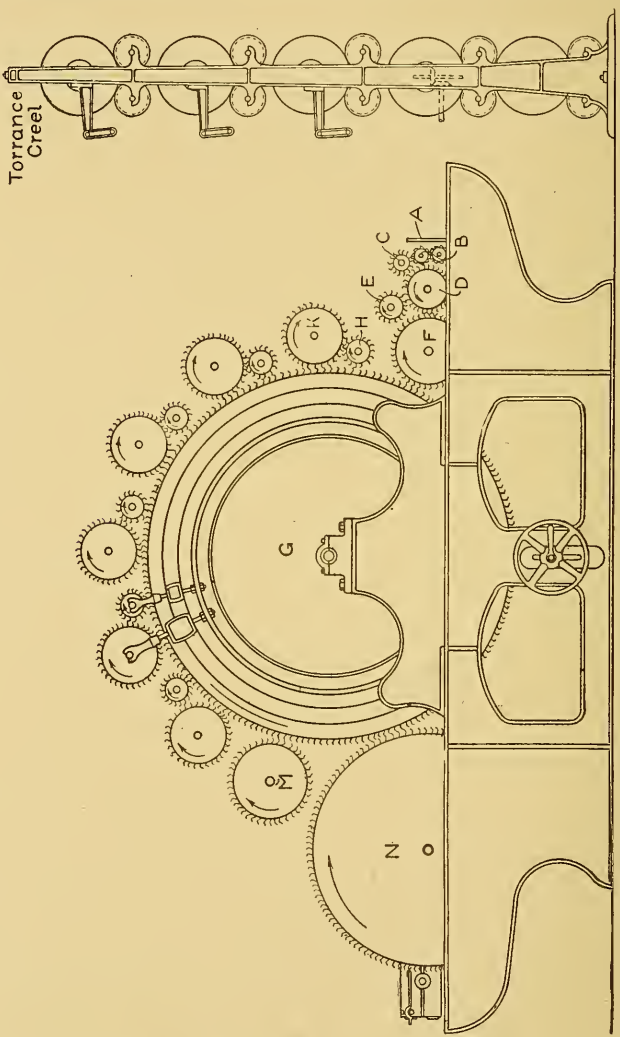


Fig. 73. Side Elevation of Second Breaker Card with Torrance Creel.

to the first breaker. The feed rolls are clothed with diamond pointed wire and there is a wipe roll to keep the top roll clean. The wipe roll is covered with the same wire that is on the feed rolls.

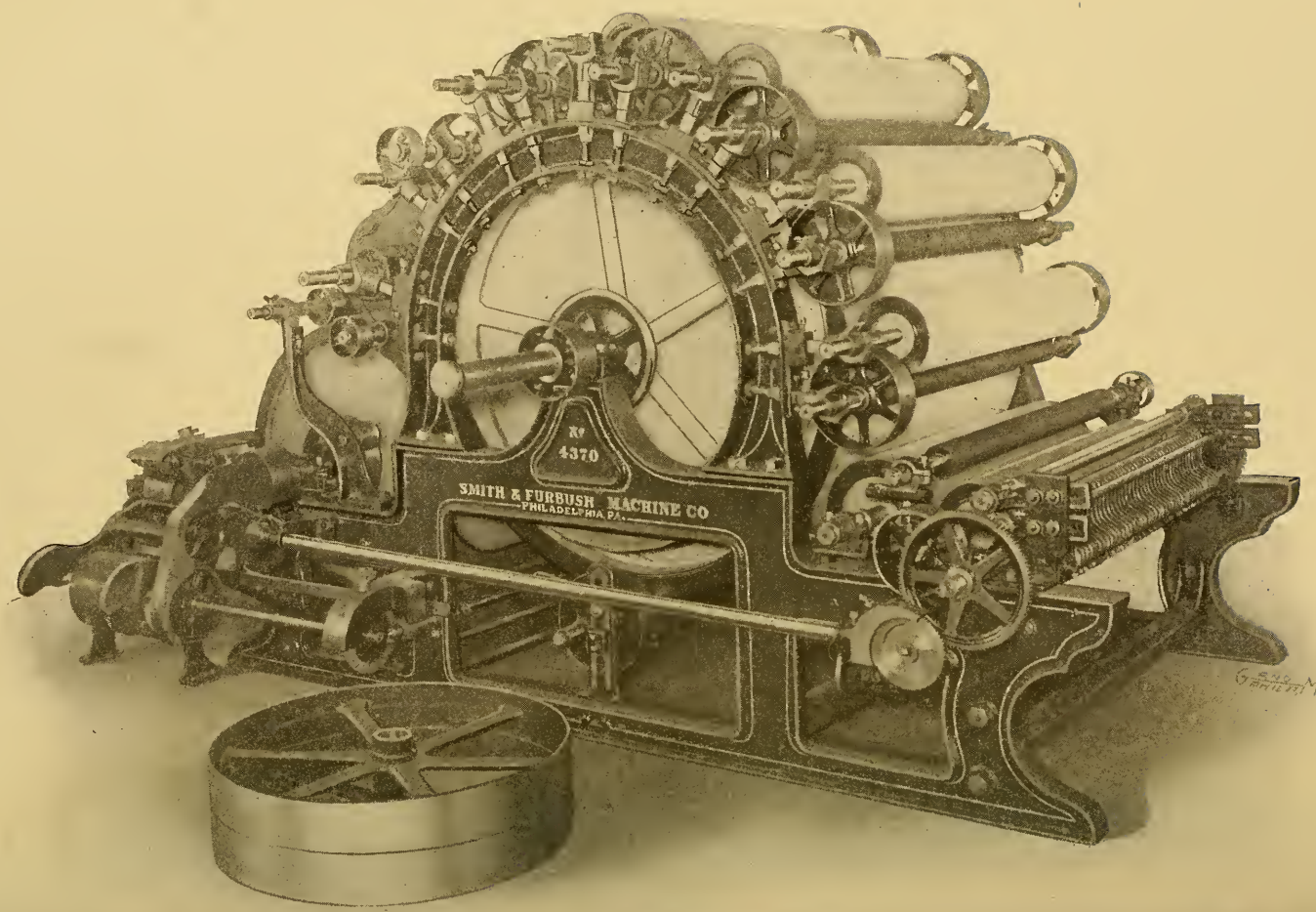

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Fig. 74 shows the method of driving the feed rolls, which is common to both the first and second breaker cards. As previously stated, it is very important in woolen carding that the feed and delivery should be absolutely even, as there are no after processes

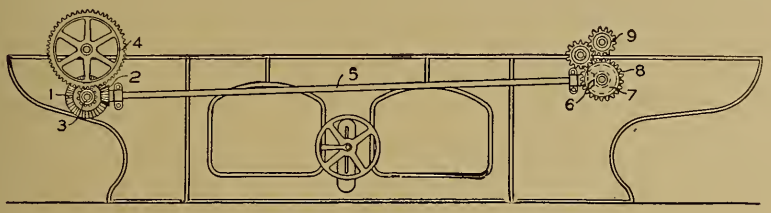


Fig. 74. Gearing for Feed Rolls and Doffer.

in which unevenness can be rectified, such as there are in worsted manufacturing. This mechanism positively controls the feed and delivery of the card and regulates the weight of the sliver to a fine degree.

Referring to Fig. 74, 1 is a bevel gear on a stud at the feed end of the machine, 2 is bevel gear on the shaft 5, 3 is a gear on the same stud as 1 and drives the gear 4, which is on the feed rolls, 5 is the connecting shaft from the doffer to the feed rolls, 6 is a bevel gear on the shaft 5, at the doffer end of the machine, and drives the bevel gear 7. The gear 8 is on the same stud as 7 and meshes with the gear 9, which is on the doffer shaft.

TABLE 8

SECOND BREAKER CARD

Name	Dia. (bare)	Dia. (clothed)	Revs. per m.	Surface speed clothed	Wire	Size of Wire	Counts	Crowns	Written
Feed rolls	1¾″	2½″	Change	Change	△ Steel twilled	No. 22	30	6	$\frac{30}{6}$
Wiper	1¾″	2½″	Change	Change		No. 30	80	10	$\frac{80}{10}$
Lickerin	5½″	6¼″	112.5	184.1	△ Steel twilled	No. 26	45	7	$\frac{45}{7}$
Lickerin Fancy	3″	4¾″	350	435.3		No. 30	60	8	$\frac{60}{8}$
Tumbler	9″	9¾″	138.5	353.6	Steel twilled	No. 34	90	12	$\frac{90}{12}$
Strippers	3″	3¾″	350	343.7	Steel twilled	No. 34	90	12	$\frac{90}{12}$
Workers	7″	7¾″	4	8.12	Steel twilled	No. 34	90	12	$\frac{90}{12}$
Main Cylinder	48″	48¾″	90	1149	Steel twilled	No. 34	135	8	$\frac{135}{8}$
Fancy	10″	11¾″	525	1615	Steel twilled	No. 34	70	8	$\frac{70}{8}$
Doffer	30″	30¾″	7.2	57.9	Steel twilled	No. 34	90	12	$\frac{90}{12}$

Returning to Fig. 73 the parts of the second breaker are as follows: A is a guide plate which guides the ends from the creel to the feed rolls B. C is the wipe roll which, as explained above, is clothed with the same wire that covers the feed rolls. Its purpose is to keep the feed rolls clean. The wool is passed from the feed rolls to the lickerin D, and from there it is passed to the tumbler F. Over the lickerin is placed the lickerin fancy which cleans the lickerin. The wool is passed on to the main cylinder by the tumbler and receives the same carding and stripping process that is performed in the first breaker card. The fancy M raises the wool to facilitate the work of the doffer N. Table 8 gives all the particulars of the second breaker card.

FINISHER CARD

This, as implied by the name, is the last card in the set. It differs somewhat from the first and second breakers, although the same general principles are found. In place of the single doffer, as on the first two cards, there are two doffers, one over the other,

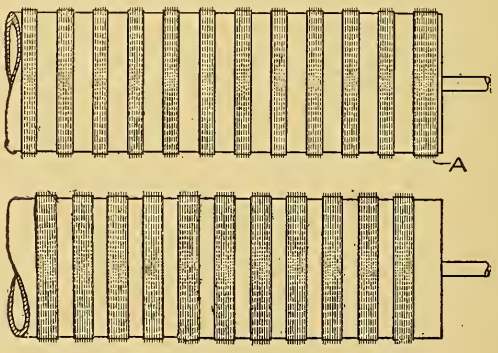


Fig. 75. Ring Doffers.

both of which are clothed with rings of card clothing. The method of covering these doffers is to place, alternately, strips or rings of card clothing and strips of leather, the latter to fill the spaces between the rings of card clothing and to assist in keeping them in position.

The width and number of these rings vary with the width of the card and the number of slivers of roving required. Each strand of the roving is condensed from the ribbon of carded wool stripped from the cylinder by a ring on a doffer. The usual num-

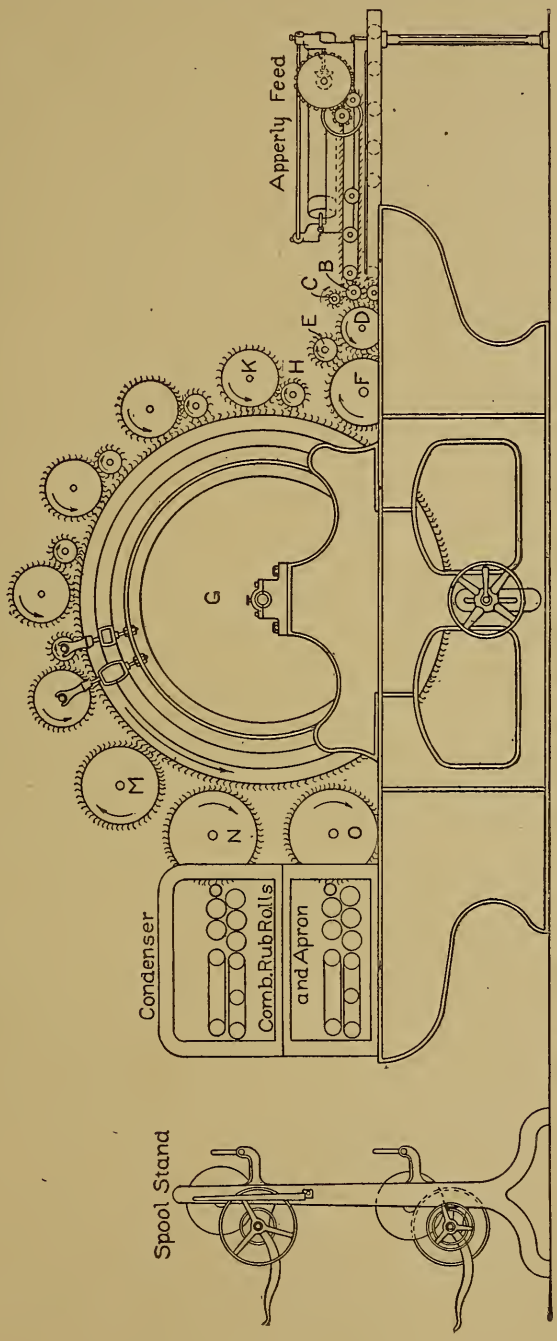


Fig. 76. Side Elevation of Finisher Card, with Apperly Feed, Condenser, and Spool Stand.

ber of rovings from a forty-eight inch card is forty-eight, allowing for two outside or waste ends. These waste ends are the result of using the Apperly or other similar feeds which double the sliver on the feed apron of the finisher card.

On fine work sometimes as many as seventy-two ends are taken from a forty-eight inch card, the rings, of course, being set close together. On a sixty inch card, sixty ends in addition to the two outside waste ends are usually taken, but on fine work as many as eighty ends may be taken.

Fig. 75 shows a diagram of top and bottom doffers with rings and spaces. It will be noted that the rings are alternated so as to cover the whole surface of the main cylinder.

The end ring marked A is the waste end ring. One of these rings is on the left end of the bottom doffer and the other is on the right end of the top doffer. The rings as stated above, take the wool from the edges where it is always heavier on account of the doublings of the Apperly feed. These waste ends are disposed of by waste end conveyers of which there are several kinds; the one generally used being the method of conveying the waste back to the feed of the first breaker through a pipe by means of a fan. In some cases the waste ends are wound on to small spools, then pulled apart and thrown into the first breaker feed.

The clothing on the rings should receive the most careful attention, and the wires be kept sharp and in proper position or the roving cannot be uniformly even.

Fig. 76 shows the main features of the finisher card, and it will be seen that it differs very little from the first and second breakers. The chief difference is of course the use of two ring doffers in place of the single doffers on the other cards of the set, and also the condenser which is attached to the finisher card to condense the strands of carded wool, taken from the main cylinder by the ring doffers, into rovings.

There is a gear on the bottom doffer shaft for changing the speed of the feed rolls, but this will not change the weight of the rovings from the finisher card, as that depends upon the amount of wool delivered to the finisher from the second breaker. In order to change the weight of roving when the second breaker and the finisher are coupled together with an Apperly or similar

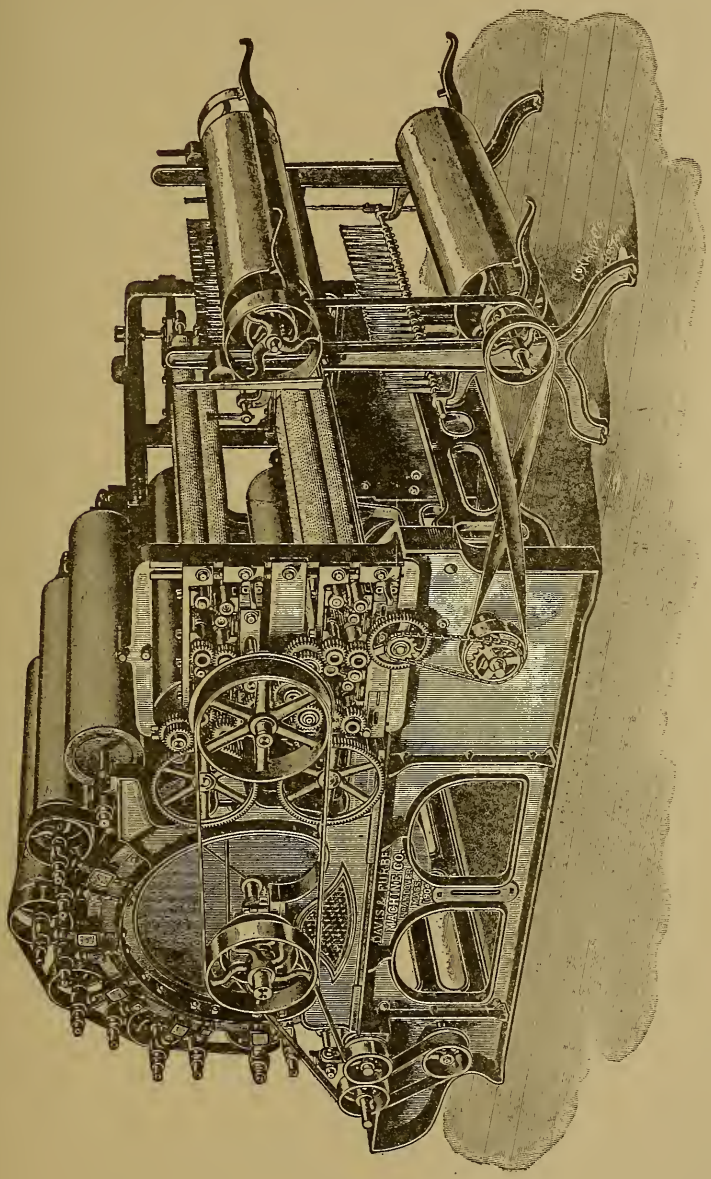


Fig. 77. Finisher Card with Condenser.

feed, it is necessary to change the amount of wool delivered by the second breaker, but where the finisher is fed by a creel independent of the second breaker, the weight of roving may, of course, be regulated independently.

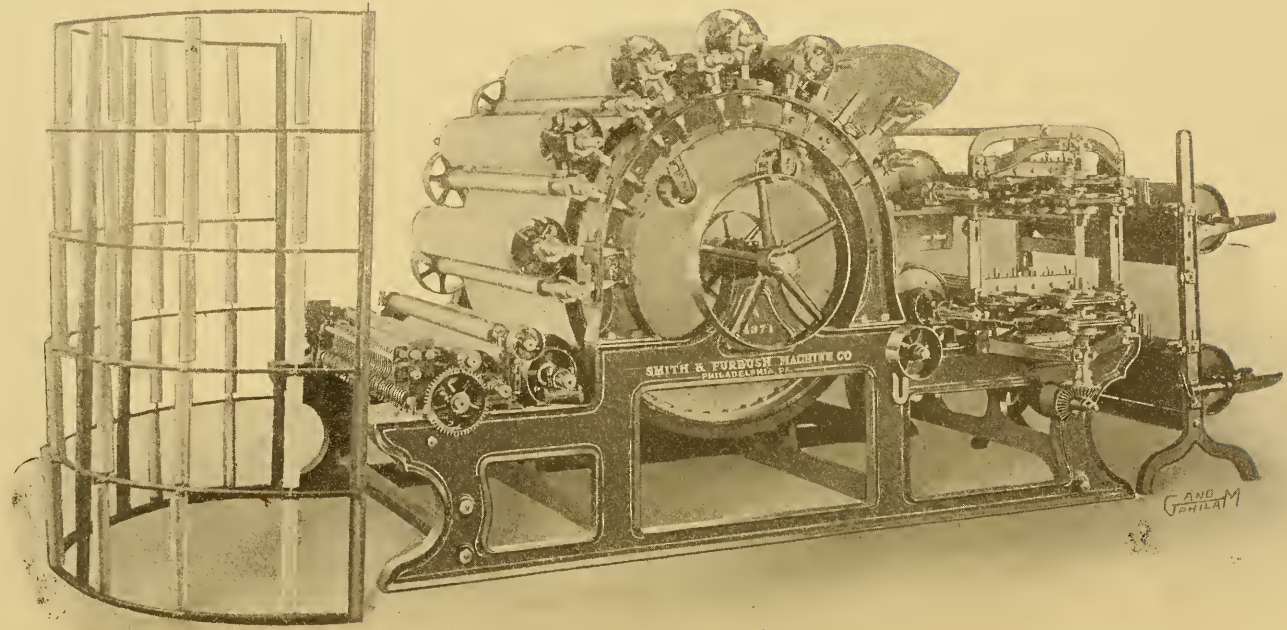
Some carders prefer to run the workers on the finisher in the opposite direction to that in which they are run on the first and second breakers, claiming that it prevents flyings and that the workers are stripped more evenly than when running in the ordinary way. With a worker running in the ordinary direction a large portion of its surface is covered with wool, which is held until it comes in contact with the stripper, with the result that the stripper is apt to pull off the wool in bunches or lumps. This cannot occur if the worker is reversed, as the wool covers only about one-fifth of the surface of the worker before it comes in contact with the stripper and is returned to the cylinder. To reverse the workers, the belt which drives them is crossed.

It will be noted by again referring to Fig. 76 that the feed rolls B, wipe rolls C, lickerin D, lickerin fancy E, and tumbler F, are the same as in the second breaker. The strippers H and the workers K are in the same relative position to the other parts but

TABLE 9

FINISHER CARD

NAME	Dia. (Bare)	Dia. (Clothed)	Revs. per m.	Surface speed clothed	Wire	Size of Wire	Counts	Crowns	Written
Feed Rolls	1½″	2″	Change	Change	△	No. 22	30	6	$\frac{30}{6}$
Wiper	1″	1¾″	Change	Change	Steel twilled	" 30	80	10	$\frac{80}{10}$
Lickerin	4½″	5″	112.5	144.0	Cone	" 24	25	6	$\frac{25}{6}$
Lickerin Fancy	3″	4¾″	350	435.3	Steel twilled	" 32	65	10	$\frac{65}{10}$
Tumbler	9″	9¾″	138.5	353.6	Steel twilled	" 35	100	12	$\frac{100}{12}$
Strippers	3″	3¾″	350	343.7	Steel twilled	" 35	100	12	$\frac{100}{12}$
Workers	7″	7¾″	4	8.12	Steel twilled	" 35	100	12	$\frac{100}{12}$
Main Cylinder	48″	48¾″	90	1149	Steel twilled	" 35	150	8	$\frac{150}{8}$
Fancy	10″	11¾″	525	1615	Steel twilled	" 35	75	8	$\frac{75}{8}$
Ring Doffers	12″	12¾″	11.6	38.7	Steel twilled	" 35	90 on top 100 on bottom		



FURBUSH CONDENSER CARD
Smith & Furbush Machine Co.

the workers revolve in the opposite direction. The fancy M works exactly the same as in the second breaker card, raising the wool so that it may easily be taken from the cylinder by the ring doffers N and O, which are covered with strips of fillet or card clothing as shown at Fig. 75.

The Apperly feed and condenser are also shown in Fig. 76, the object being to show their relative positions to the other parts of the finisher card.

The ribbons, doffed from the main cylinder by the ring doffers, are passed through the combination rub rolls and apron of the condenser and delivered to the jack spool in the spool stand. There are two spools in the stand and two sets of combination rub rolls and aprons, or one for each of the doffers.

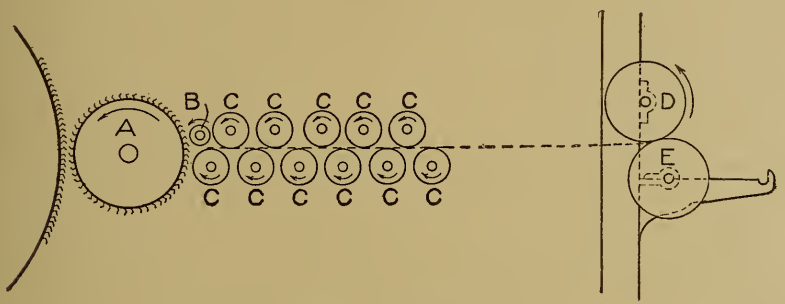


Fig. 78. Condenser.

Before passing on to detailed explanations of the condensing and feeding mechanisms, it should be remarked that the finisher card should receive the most careful attention, as the quality of the roving produced depends upon the manner in which the stock is manipulated in this card. However perfect the carding is performed in the first and second breakers, good results cannot be obtained if the finisher is not properly set. Table 9 gives all the parti culars of the finisher card.

Condenser. The condenser is attached to the finisher card, and consists of a mechanism for taking the ribbons of carded wool from the ring doffers and condensing or rubbing them into rovings. The speed of the condenser must be such as to condense each ribbon into a round thread of roving, and the stroke of the rubbers must be a little wider than the widest ring.

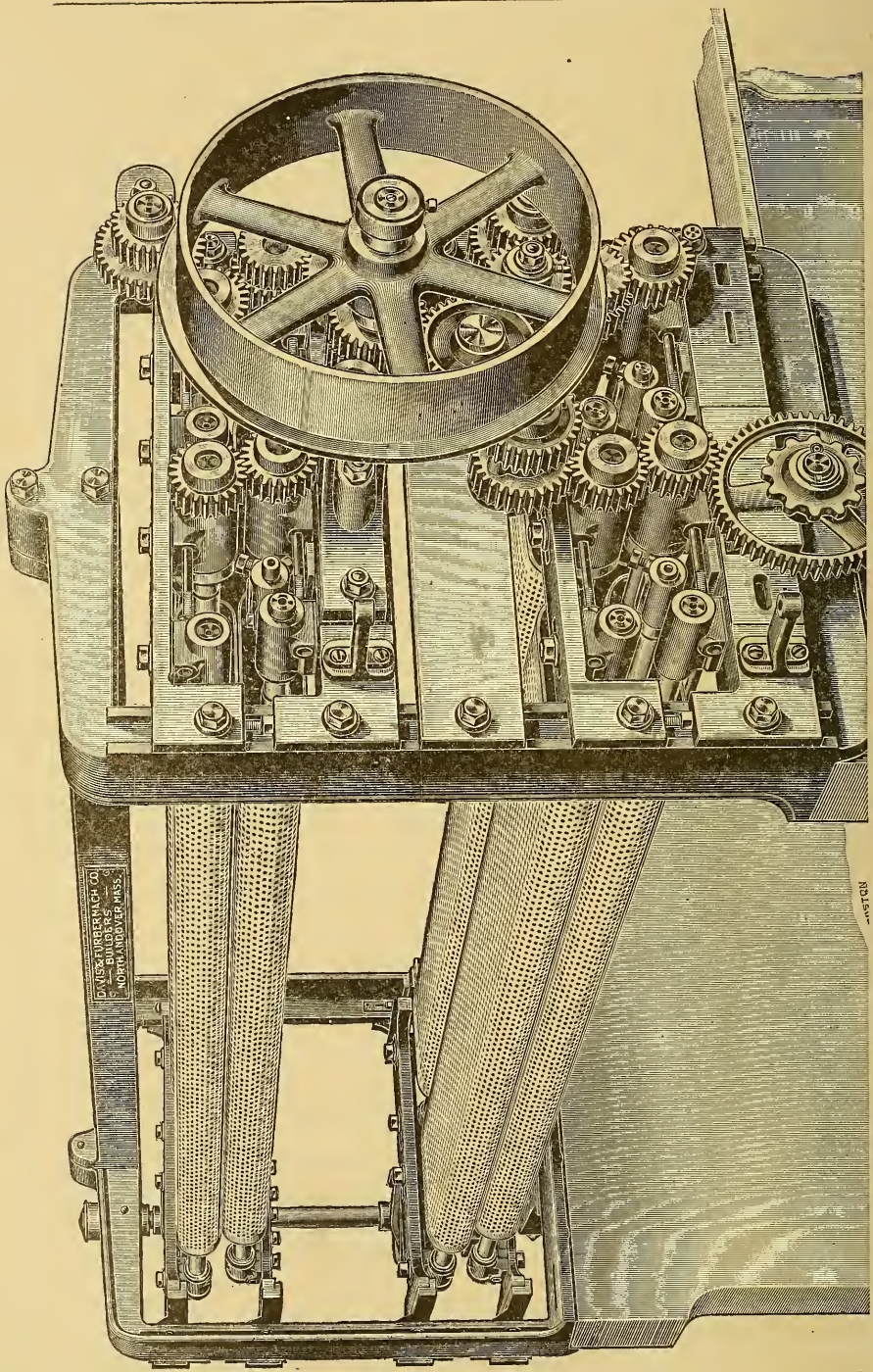


Fig. 79. Davis and Furber Double Apron Condenser.

The roll which takes the stock from the ring is termed a wipe or strip roll and is usually covered with corduroy, although in some cases it is covered with fillet leather. It should be drafted so as not to strain the roving between the doffers and the rub rolls and apron. The rolls or aprons must be set close enough to rub a moderately hard roving. In some cases on coarse open stock it is necessary to set the rolls down hard and increase the speed of the rub rolls or aprons.

While there are several styles of condensers the later ones are such a vast improvement over the old styles that it would be a waste of time to attempt to explain the old-fashioned ones. At the present time all kinds of stock may be handled with very little trouble in an up-to-date condenser. The object of all the different styles of condensers is the same; *i. e.*, to rub the roving between two leather surfaces to give it enough strength and stability to prevent injury while it is being wound upon the spool, and later while it is being wound off the spool on the spinning mule.

An illustration of a condenser is given at Fig. 78. A is the ring doffer; B, wipe roll; and C, rub rolls. The number of rub rolls varies according to the stock and the different ideas of various carders; some have seven, others have nine, and still others have fifteen. Where there are two ring doffers there are also two sets of rub rolls.

The wipe roll B passes the stock to the rub rolls C and the rolls revolve in the direction of the arrows. A transverse or reciprocating movement is also imparted to the rolls by means of eccentrics placed at one side of the condenser. The rub rolls are covered with leather, and as before stated, rub the ribbon of waste into a round sliver of roving. This rubbing or condensing motion takes the place of twist, which is similarly used in other cases to give strength to rovings and thread.

There is slight draft between each pair of rolls which tends to keep the roving straight and smooth. After passing through the condensing rolls the roving is wound on spools (D. Fig. 78).

Apron Condenser. The apron condenser is considered the best for all kinds of stock and particularly for very low stock. There are usually two pairs of aprons to each doffer. The strands of wool pass between the aprons which have a revolving and also a

transverse motion which rubs the wool into a smooth round roving.

The double deck apron condenser built by Davis & Furber is shown at Fig. 79. Two belts are required to drive the condenser. One belt drives the eccentrics which impart the transverse or reciprocating motion, and the other imparts the revolving motion to the aprons.

Apperly Feed. As a rule the sliver is carried from the second breaker and presented to the feed rolls by a device named the Apperly feed. This is considered one of the best devices for feeding finisher cards, as it makes the operation of two cards continuous.

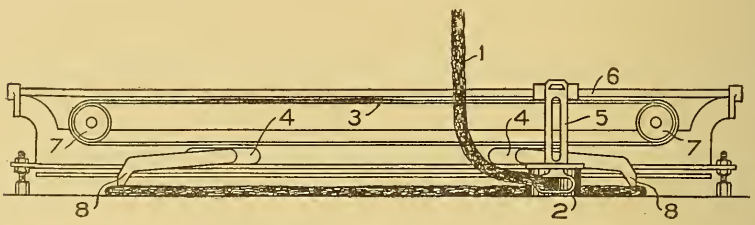
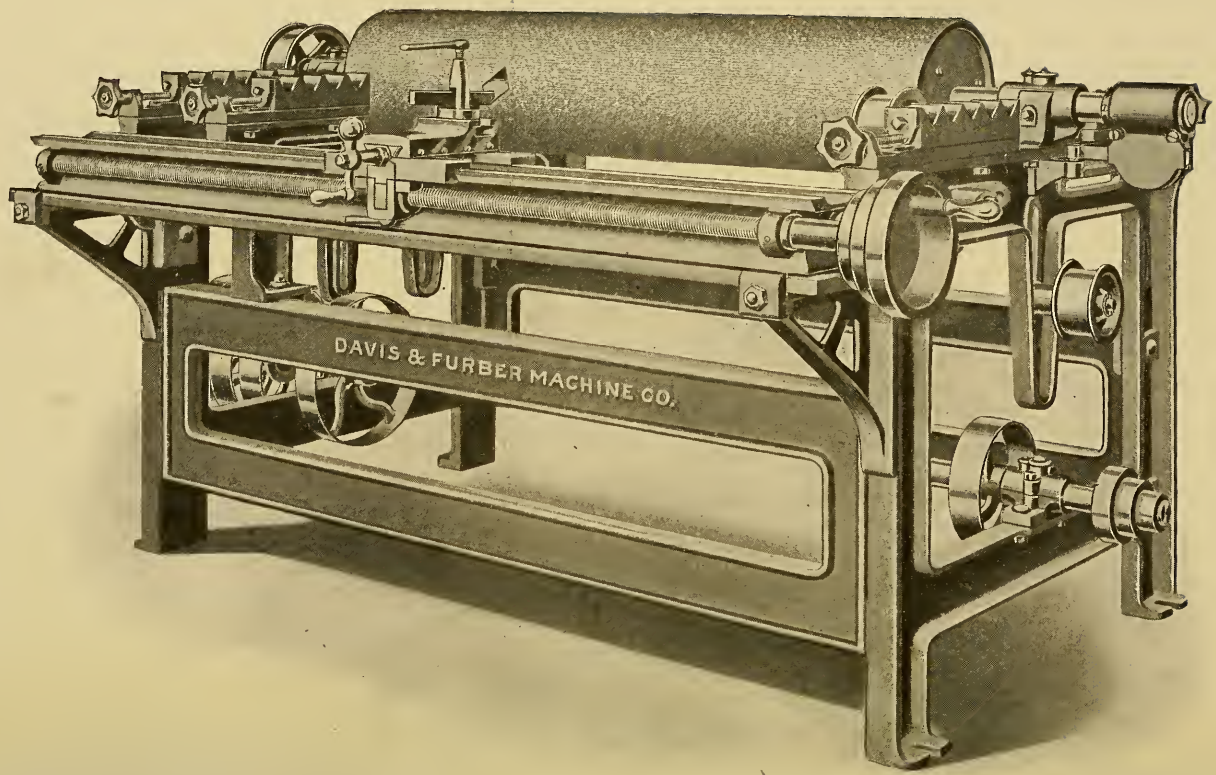


Fig. 80. End View of Apperly Feed.

The sliver from the second breaker is twisted as it passes through the rotating tube and thereby is given strength to be carried overhead to the Apperly feed, which is attached to the finisher card.

The number of doublings on the feed apron varies according to the width of the card. The usual number for forty-eight inch cards is forty, but with smaller ends and wider cards, the number runs somewhat higher. For a sixty inch card, the number of doublings runs as high as sixty. The illustration shown at Fig. 80 shows the method of laying the slivers on the apron of the Apperly feed. The pulley 7 carries the belt 3, which travels across the apron in a diagonal direction. Attached to this belt is the dog 4, which is about three inches long and works in the slot of the carrier 5. The carrier works upon the shaft 6. The sliver 1 passes through the rolls 2, and is laid on the feed apron by the motion given to the carrier 5 by the belt 3.

In Fig. 81 the feed rolls of the card are shown at 12; also the wipe roll at 13. The carrying aprons 1 carry the stock, which is laid transversely across them, to the feed rolls. The carrier 5



CARD GRINDER FOR WORKERS, STRIPPERS, ETC.

Davis & Furber Machine Co.

travels on the rod 6. Two latches marked 8 in Fig. 80 are lifted by the carrier and fall down into the loop formed by the sliver when the carrier returns, and thus hold it from drawing back as the next layer is placed on the apron. Apron 1 should travel just fast enough to lay the slivers close together, yet not slow enough to crowd them.

The speed of the apron is controlled by the gear on the doffer shaft of the finisher card, which will drive the feed roll and apron faster or slower as desired. A larger gear will drive them faster and a smaller one will drive them slower. The changing of this gear will not change the amount of wool fed to the finisher, or the roving, but merely changes the speed of the feed rolls and feed apron.

The gear 17 is driven from the side shaft of the finisher card and is fastened to the bottom feed roll of the Apperly feed. On the same shaft is a gear 16, which drives a smaller gear 14, and

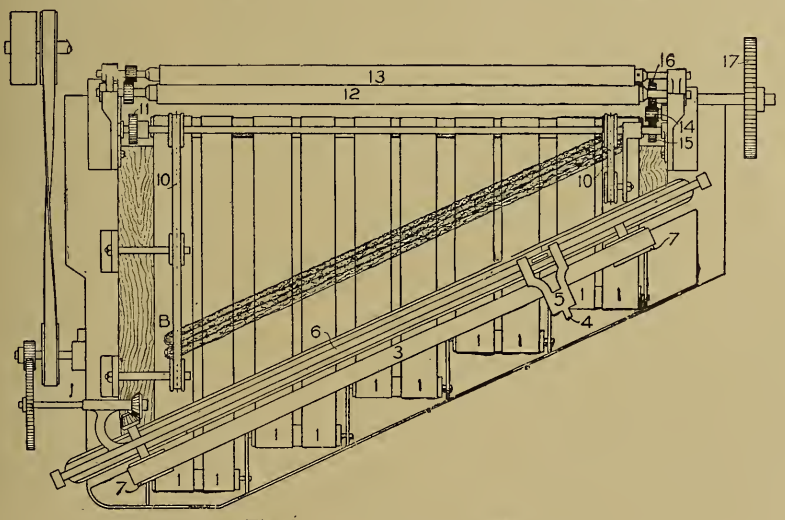


Fig. 81. Plan of Apperly Feed.

this in turn drives the gear 15 on the apron roll shaft. The apron rolls turn in the direction of the feed rolls, thus causing the aprons to carry the stock forward.

The outside bands are made of leather and are perforated with short wires which keep the stock straight on the other bands or aprons, which are usually of a heavy woven cotton cloth. The

two spike straps 10 serve to more effectually keep the stock straight on the aprons, in fact this is their special office. To facilitate this work they are equipped with sharp wires about $1\frac{1}{2}$ inches long and travel in the same direction and at the same speed as the wool on the aprons. As each layer of wool goes forward, it is taken by these spike straps which hold the ends and prevent the natural contraction of the slivers. The gear 11 on the spike strap shaft is driven from the gear on the apron roll.

When this feed is used there is always a waste end on each side of the condenser, caused by the doubling of the sliver at each end as shown at B in Fig. 81. The roving from these two ends is always heavier, so, of course, threads made from this roving would be heavier than the rest of the yarn.

Stripping the Cards. After running for some time the clothing of cards becomes filled with short fibers and much of the refuse matter which is removed in the carding process. In some instances, the card becomes so filled with this refuse that the operation of carding is seriously affected. To remove this matter, the cards must be cleaned or stripped. When the card is to be stripped, the belts are thrown off and the stripping performed by means of hand cards, similar to those described in the early part of worsted carding.

The first breaker card requires more cleaning than the second breaker card, and the second breaker card requires more cleaning than the finisher card. The reason for this is that as the wool advances from one machine to another, much of the dirt is being constantly removed. Generally speaking, the first breaker should be cleaned every day. However, much time is saved by cleaning the main cylinder doffer one day, and cleaning the whole card the next day. The second breaker may be cleaned every other day, while two strippings a week are sufficient for the finisher card.

The doffers of all the cards should be given especial attention and the ring doffers of the finisher card should receive almost constant care. The first operation is to disconnect the feed rolls, and allow the card to run for several minutes in order that as much of the stock as possible may be run through. The belts are then removed and the fancy workers and strippers are taken to a rack and cleaned with a hand card or comb. The main cylinder and doffer

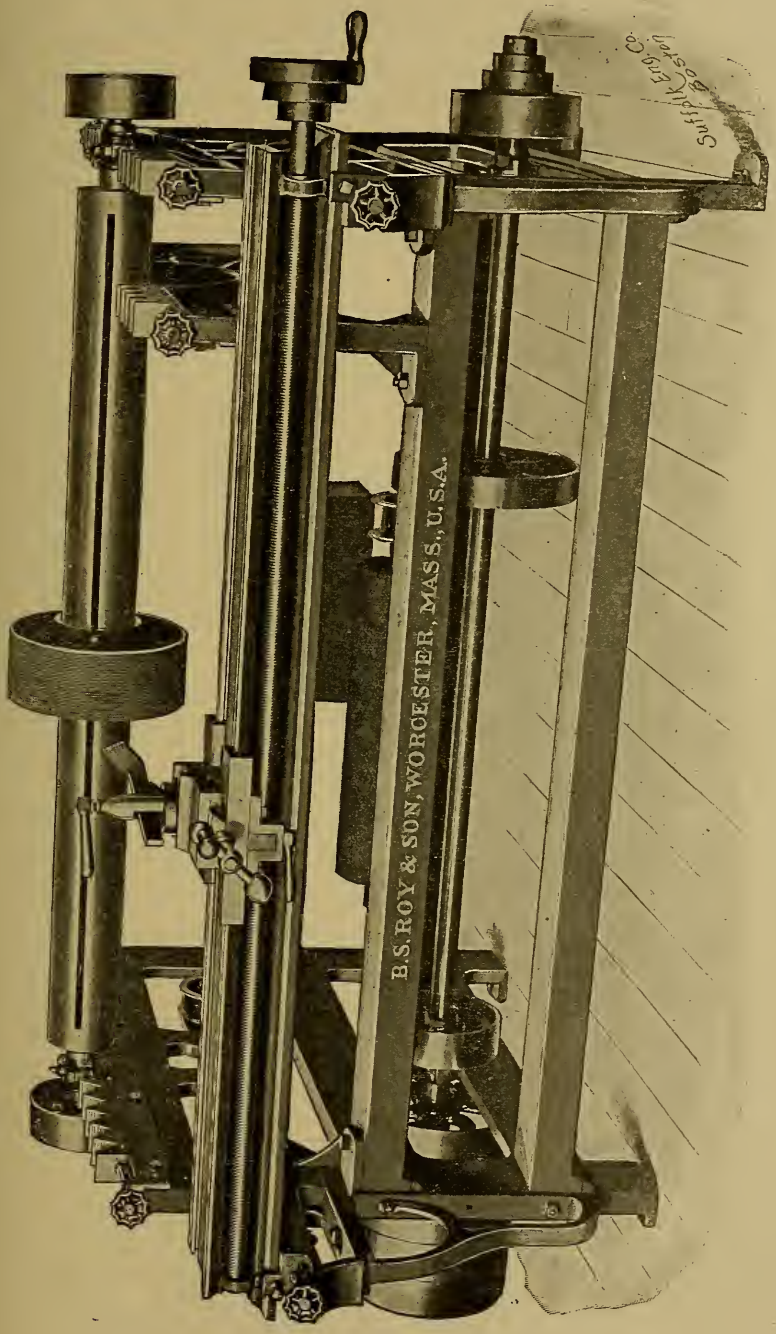


Fig. 82. Grinding Frame with Traverse Grinder.

are necessarily stripped in their bearings, as are also the lickerins and tumblers. Before connecting the feed rolls it is a good plan to allow the card to run for a few minutes after cleaning in order to remove loose particles of refuse. The settings should also be looked over very carefully. The wool is then allowed to enter by the feed rolls being connected, and after the sliver has attained its correct weight, the card needs little more attention until the next day.

In stripping the ring doffer of the finisher card, a special hand card should be used, as this is perhaps the most delicate operation of cleaning in the card room.

Grinding. As explained under the subject of grinding in worsted carding, there are two kinds of points obtained in this process. The statements made under that heading apply equally well in the present case. If the cards are properly set and given proper care, very little grinding is necessary, for it is undoubtedly a fact that a large amount of card clothing is spoiled by grinding too often, and by over-grinding.

The main cylinder and doffer are ground in their own bearings, the bearings of the grinder being bolted to brackets on the frame of the card. When grinding the cylinder its direction is reversed in order to grind against the back of the teeth, as explained in grinding worsted cards.

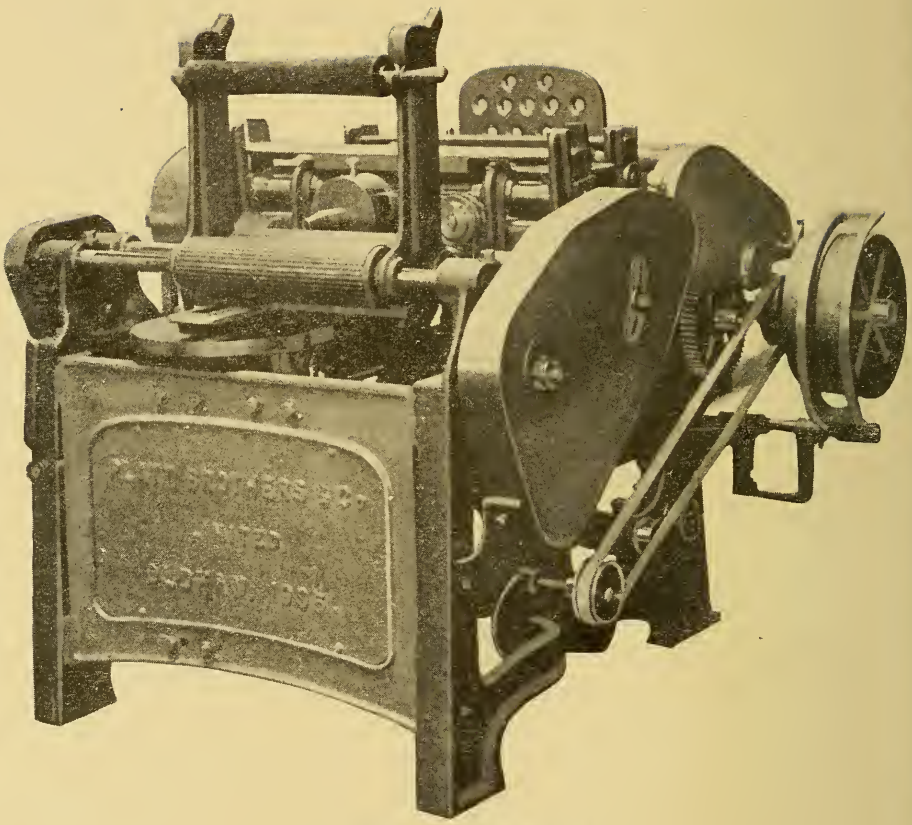
The speed of the doffer should be increased, when grinding, by putting a pulley on its shaft and driving it by means of a belt from the main cylinder shaft. The grinder may be driven from pulleys fastened to the stripper shafts of the card. Great care should be used to have the grinder adjusted properly, so one side of the cylinder will not be over-ground. The doffer should be moved a little distance from the cylinder when grinding.

Workers, strippers, fancy, and tumbler, are not ground in their bearings, as in the case of a main cylinder and doffer of the card, but are taken to a grinding frame such as the one illustrated in Fig. 82. It will be noted that this machine consists of a frame upon which is mounted a traverse grinding wheel. Two rolls may be ground simultaneously as shown at Fig. 64 by putting one on each side of the grinding roll. Pulleys are fastened to the shafts

of the rolls by set screws, and are driven by means of a belt from the bottom shaft of the grinding frame.

Imperfect Roving. In the general consideration of woolen carding it was stated that careful attention should be given the carding operation as the roving from the finisher card and condenser goes direct to the spinning frame, and there is no opportunity to correct defects made in carding.

Perhaps the most common imperfection in rovings are the thick places called *twits*. These places cause uneven yarn and consequently uneven cloth. There are many causes which produce uneven roving; twits, in some instances, being the direct result of having the scouring liquor at too high temperature. Careless oiling before carding is a prolific cause of imperfections, as is also poor setting of the parts of the card and defective card clothing. However, if the various parts of the card are kept in good working order, the wool fed evenly, the proper grade of wool used for the size of roving required, and the cards not "crowded," there will be very little defective work.



GILL BOX WITH BALLING HEAD
Platt Bros. & Co.

WOOLEN AND WORSTED SPINNING

PART III

PREPARING

While most of the wools used in the manufacture of worsted yarns are carded, there are some long stapled varieties in the manufacture of which carding gives place to *Preparing*.

The operation of preparing consists in subjecting the wool to the operation of a number of machines, termed *gill boxes*, which arrange the threads in the parallel order characteristic of worsted yarns; and, unlike carding, it does not reduce the average length of the fibers to any extent. Fig 83 shows a representative gill box, and will be explained later.

There are, perhaps, no two processes in worsted manufacturing for attaining the same end, which differ so widely in principle and practice as do carding and preparing; yet the results are so similar that in a medium quality wool it is doubtful if an expert could tell whether the wool had been carded or prepared. Preparing is suitable only for long wools, while carding is for shorter grades.

Preparing, like finishing gilling, which will be taken up at the proper time, is a continuous process of combing. The essential parts of each machine are very simple; and for consideration of their principles, it is best to regard them quite apart from the mechanism which moves them. Every gill box has front and back rolls and a set of fallers, as shown at Fig. 84. The action of the machine depends entirely upon the relative speeds of these three parts. The motion of the rolls is rotary, and that of the fallers is horizontal, but all three move the wool forward in the same direction. To compare their action, an experiment will be tried:

Assume that the back rolls A are running with a piece of tape between them, and that they draw one yard in $1\frac{1}{2}$ minutes. The

fallers B—which are steel bars in which pins are set—would draw six inches in the same period of time, while the front rolls C would draw no less than 36 inches. This relative amount of speed is termed *draft*, and the proportions taken are suitable for the first preparing box.

Drafts. The size of the essential parts and their relative speeds vary for each consecutive machine in a set of preparing machines, but in all gill boxes the front rolls move faster than the fallers, and the

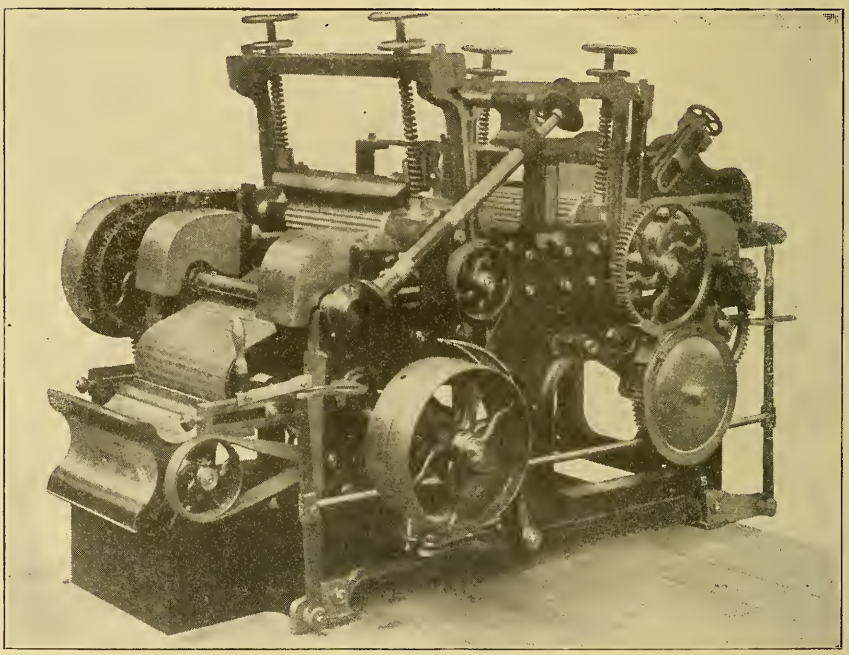


Fig. 83. Type of Gill Box.

fallers move faster than the back rolls. The relation of the speed of the fallers to the speed of back rolls will be called the *back draft*; that of the front rolls to the fallers will be called the *front draft*, and that of the front rolls to the back rolls will be called the *total draft*.

Tabulating the figures used in the above experiment according to this explanation we have the following:

Back Rolls deliver 1 yard in $1\frac{1}{2}$ minutes.
Fallers deliver 6 yards in $1\frac{1}{2}$ minutes.
Front Rolls deliver 36 yards in $1\frac{1}{2}$ minutes.

Therefore, the back draft is six to one, the front draft also is six to one;

and the total draft is thirty-six to one. This is further proved in the gearing calculations.

In all fine wool gill boxes, however, the back draft is so small that very often there is little difference between the sum and the multiple of the two drafts, hence the principle is not always clearly understood. For instance, a gill box for fine wool might have a back

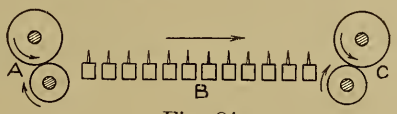


Fig. 84.

draft of one and one-quarter, and a front draft of four, which would give a total draft of five ($1\frac{1}{4} \times 4 = 5$.) If the two drafts are added the sum would be five and one-quarter ($1\frac{1}{4} + 4 = 5\frac{1}{4}$), showing a difference of only one-quarter.

Another machine might have a back draft of one and one-half and a front draft of four, which would give a total draft of six ($1\frac{1}{2} \times 4 = 6$). If, in this case, the front and back drafts were added, the sum would be five and one-half ($1\frac{1}{2} + 4 = 5\frac{1}{2}$), which gives a difference of one-half.

These examples are given merely to forcibly impress the fact that the total draft of all gill boxes is the product of the front and back drafts multiplied together. As may be seen by reference to Table 10, the drafts are much larger for the preparing operations.

TABLE 10

SET OF LONG WOOL PREPARING, BACKWASH, AND FINISHING GILL BOXES

	Back Rolls Dia.			Front Rolls Dia.					Drafts		
	Top	Bottom	Flutes per inch.	Top	Bottom	Flutes per inch	Pitch of Screw	Ratch	Back	Front	Total
1st sheeter.....	6	$3\frac{1}{2}$	4	5	$3\frac{1}{2}$	3	$1\frac{1}{4}$	24	6	6	36
2nd "	6	$3\frac{1}{2}$	4	5	$3\frac{1}{2}$	3	$1\frac{1}{4}$	24	6	6	36
3rd can box.....	6	3	4	5	3	4	1	23	4	4	16
4th " "	5	3	5	5	3	4	$\frac{7}{8}$	22	3	4	12
5th " "	$4\frac{1}{2}$	3	5	5	$2\frac{1}{2}$	5	$\frac{7}{8}$	21	$2\frac{1}{2}$	4	10
after.....											
6th backwash	$4\frac{1}{2}$	3	5	5	$2\frac{1}{2}$	5	$\frac{7}{8}$	20	$2\frac{1}{4}$	4	9
7th "	4	3	5	5	$2\frac{1}{2}$	5	$\frac{7}{8}$	20	$2\frac{1}{4}$	4	9
8th "	4	3	5	5	$2\frac{1}{2}$	5	$\frac{7}{8}$	20	$2\frac{1}{4}$	4	9
finishing											
2 gill boxes	3	$2\frac{1}{2}$	6	4	$2\frac{1}{2}$	6	$\frac{9}{16}$	20	$2\frac{1}{4}$	4	9

Ratch means distance between back and front rolls (center to center).

The particulars given in the table are from a set of preparing gill boxes for long wool. The drafts given may be taken as a fair average although they would, of course, be varied according to the quality of the wool being prepared. It will be noted that the back draft is the greatest at the first gill box, steadily decreasing as the wool

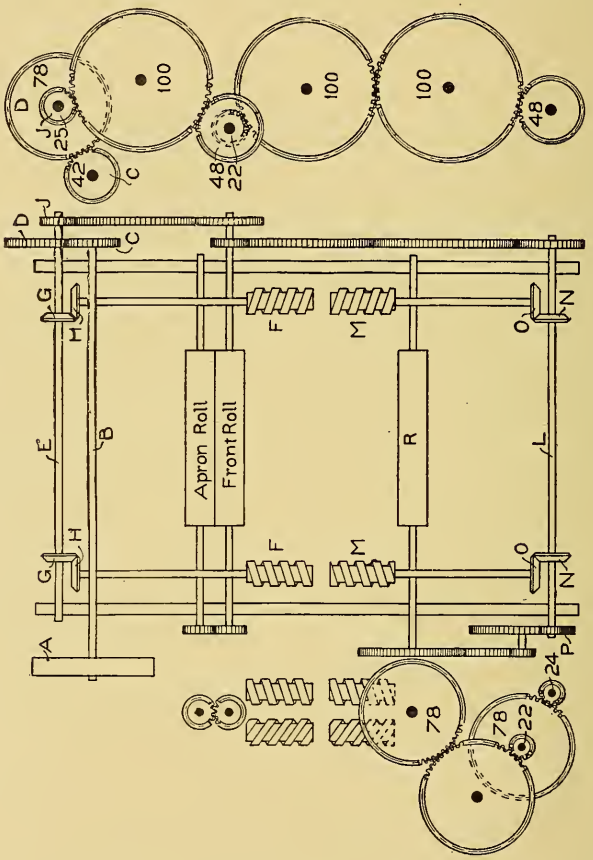


Fig. 85. Plan of Machine with Two Sets of Fallers.

advances, until it has been reduced to two and one-quarter at the sixth box, which immediately follows the back-washing. The total draft varies slightly more than the back draft, while the front draft only changes from six to four throughout the ten processes.

The plan of a machine which is sometimes used to increase the drafting power of each machine and so reduce the number of machines necessary is shown at Fig. 85. Each of these machines has two sets

of fallers and screws, as shown at Fig. 86, while the ordinary gill box has but one set of fallers and screws, as shown at Fig. 84. The speed of all gill boxes, however, is limited to the number of fallers that can be safely dropped, from the upper to the lower screw, per minute. One hundred twenty is the maximum number for one and one-quarter inch fallers, so one hundred multiplied by one and one-quarter is the unit of production for the fallers in the second screw C. There are three drafts, each of four to one, in this box, therefore the front rolls will turn out twenty-four yards in one and one-half minutes. The

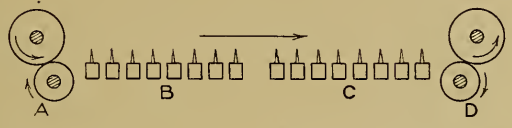


Fig. 86. Diagram of Front and Back Rolls and Fallers.

first set of fallers B will only drop one-quarter of one hundred twenty, or thirty per minute. Tabulating the above gives the following:

Back Rolls A, output 13½ inches per 1½ minutes.
First Fallers B, output 1½ yards per 1½ minutes.
Second Fallers C, output 6 yards per 1½ minutes.
Front Rolls D, output 24 yards per 1½ minutes.

We will assume that in both types of box the first fallers fix the amount of wool fed up; and in that case the weight coming through the back rolls could be no more with two sets of fallers than with one set. This box has advantages for some classes of work but is not used to as large an extent as the single box.

Referring to the plan of this machine shown in Fig. 85 the parts are as follows: A is the pulley on the main shaft B, which, through the gears C and D, drives the shaft E, which in turn drives the screws F through the bevel gears G and H. The gear J is on the end of the shaft E, and drives the front rolls through two gears of one hundred and forty-eight teeth respectively. There is a gear of twenty-two teeth on the front roll shaft, which drives the shaft L through two gears of one hundred teeth each. The back screws M are driven through the bevel gears N and O. There is a gear P on one end of the shaft L which, through a chain of gears, drives the back roll R. The apron roll is driven by a gear on the end of the front roll shaft.

To go more into the details of the preparing operation refer to the elevation shown in Fig. 87 which is a single gill box; the first of

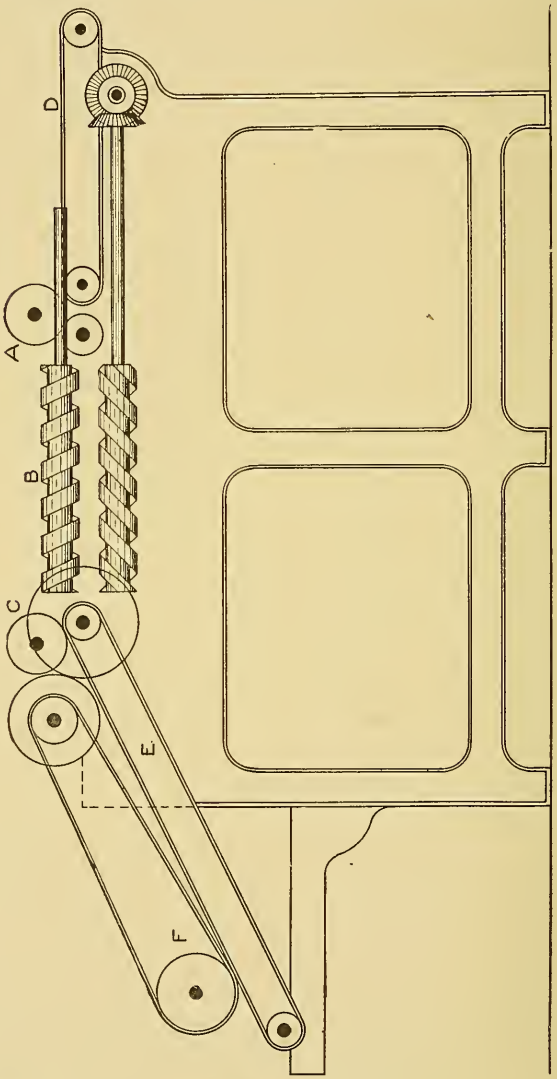


Fig. 87. Side Elevation of Gill Box.

the set. The front and back rolls and fallers of this machine are shown at Fig. 84.

All wool that is to be prepared is straightened out by hand before it is put onto the feed sheet D. The operative is expected to lay the

fibers as nearly parallel as possible, and at right angles to the back rolls. In this manner the wool passes through the rolls A, and when the fallers rise, the pins pass through the wool. As each faller rises it moves steadily away from the back rolls in the screw B, and as it travels sixteen inches before dropping into the lower screw to be carried back, any staple under thirteen inches long will be combed its entire length.

The locks of wool are in many cases so matted that the fibers would be broken if the fallers carried many pins, and as the purpose

TABLE 11

PARTICULARS OF FALLERS

	Pitch of Screw	Fallers		Pins			Pinned over	Fallers dropping per minute
		Up	Down	Rows	Per inch	Length		
1st Sheeter	1¼	14	6	2	2	1¾–2	16	120
2nd "	1¼	14	6	2	3½	1¾–1⅞	16	130
3rd Can Box	1	14	6	2	4½	1¾–1⅞	16	140
4th " "	⅞	16	7	2	5	1¾–1⅞	16	150
5th " "	¾	16	7	2	6	1¼–1⅝	16	180
6th Backwash	⅝	16	7	1	6	1¼–1⅝	16	190
7th Can Box	⅝	16	7	2	8	1¼–1⅝	16	200
8th " "	⅝	16	7	2	8	1¼–1⅝	16	200
9th Finisher	9/16	16	7	2	12	1⅛–1 5/16	16	300 Double Thread
10th "	9/16	16	7	2	14	1⅛–1 5/16	16	300 Screws

of the first box is to straighten rather than to open the wool, many fallers have only a single row of pins placed half an inch apart.

As soon as the staple is free from the back roll, it is carried along by the fallers until it reaches the front rolls C. These rolls are traveling thirty-six inches for every six inches that the fallers travel, and as soon as they get hold of any fiber, they pull it through the fallers at the same relative speed as the fallers moved through it when it was held by the back rolls.

From the front rolls the thin film of wool, which is one thirty-sixth the thickness of that which was fed to the back rolls, is carried along by the sheet E until it touches the upper sheet F. The film of wool passes around the sheet F, until a lap is formed which is thick enough to be fed to the next box. As the drafts of the two boxes are the same the amount of wool should be the same, so thirty-six revolutions around the sheet will be required before the lap is thick enough to be fed to the second "sheeter".

The process in the second box is in all respects like the first, in fact there will be no further need to refer to the action of the faller pins on the wool as in all gill boxes the combing and drafting are on the same principles as those explained, the only difference being an increased number of pins in the fallers, and the relative speeds at which the essential parts move.

Fluted Rolls. Before taking up the calculations for drafts, the output of the front and back rolls, which are fluted, must be carefully considered. There is no method of calculation that will give accurate results, as is proved by comparing the result obtained by any method of calculation with the actual output of the rolls. However, the absence of a formula by which the output may be calculated is not very serious as regards the draft, for both front and back rolls, being fluted, are affected in a similar manner. There is a leather apron which runs between the front rolls preventing the wool from sinking so deeply in the flutes.

Probably the first rolls used in gill boxes were round and smooth and the change was made because the smooth rolls did not grip the wool firmly enough. Many devices were tried before it was found that a system of fluting the rolls so the prominences of one would fit into the hollows of the other, was the best method.

An illustration of this principle is shown in Fig. 88, and it will be seen that these rolls must have enormous holding power. There is however, one feature of these rolls which demands attention: When they are running fast under normal pressure and drawing only a thin film of wool, the friction, caused by the flutes pressing against each other, will cut the wool.

This is overcome by running an endless apron between the front rolls, as these run at a greater speed than the back rolls.and have a thinner film of wool passing between them. The leather, in addition to preventing the fibers from being cut, acts as a cushion against which the flutes of the upper roll can firmly grip the wool, and so increases the drawing power of the rolls.

Calculations. In all calculations, it should be remembered that the presence of the leather apron affects the output of the machine and that the leather apron is used only between the front rolls. To understand the subject thoroughly, it will be best to consider the action of a pair of smooth round rolls. Such a pair of three-inch rolls

running at a speed of sixty revolutions per minute would deliver five hundred sixty-six inches per minute. ($3 \times 3\frac{1}{7} \times 60 = 566$.) If a leather apron were running between the rolls it would be delivered at exactly the same speed; and if these rolls, with a leather apron on them, were drawing a sliver they would deliver just five hundred sixty-six inches per minute.

With the fluted rolls the output under each of these conditions would be different, and in addition, the output would change according to the thickness or bulk of the sliver running between them. The output of a fluted roll is often stated as three and one-seventh times the diameter of the mean line D (shown in Fig. 88), which lies half way between the top and the base of the flutes. While this may be correct in some instances, it is not reliable for all cases. In the estimation of the writer the output at each revolution of the rolls cannot be much less than three and one-seventh times the extreme diameter of the rolls ; or in other words, the output cannot be less than a line drawn from point to point of all the flutes on the circumference of the roll. In the following calculations the output is calculated as the extreme diameter multiplied by three and one-seventh.

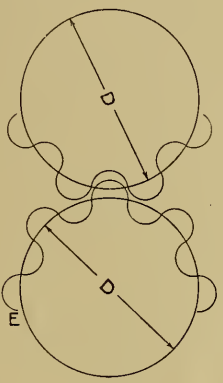


Fig. 88.

If a thin tape were run between two bare steel-fluted rolls under heavy pressure, the output for each revolution would nearly equal the total length of the line E, which represents the outside of the driving roll, and equals five times the diameter of the mean line D. If a thick leather apron were used, which, of course, could not be pressed so deeply into the flutes, the length of sliver delivered at each revolution would be much nearer to three and one-seventh times the extreme diameter; so the output of the rolls, when the leather apron is run between them, is less than the output when the apron is not used.

The draft calculations in preparing and other gill boxes are very nearly accurate because the slivers passing between the back rolls are many times the thickness or bulk of the sliver passing between the front rolls. The thick sliver presses the back rolls apart and affects

the output to about the same extent as the leather apron and sliver combined affect the front rolls.

Front Rolls. The front rolls of the gill box and the method of applying pressure to them are shown in Fig. 89. It will be noted that the lower roll A revolves in the long bearings B, which are fixed to the framework of the machine. The upper roll C rests upon roll A, and pressure is applied to it by the springs D, which are regulated by the wheels F. The wheels press against the hinged lever G in such a manner that the pressure is the same on both ends of the roll.

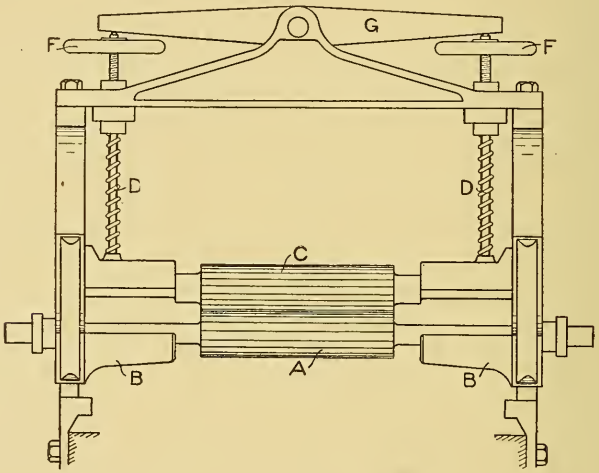
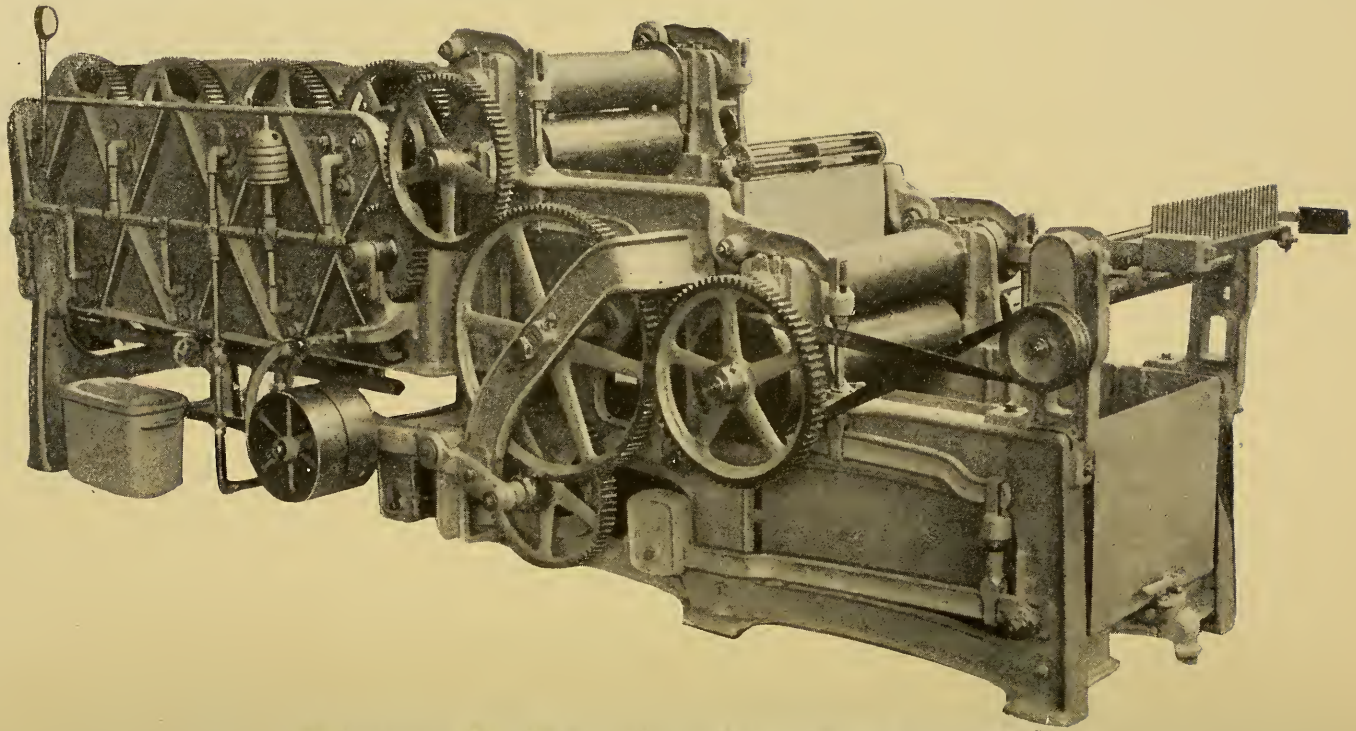


Fig. 89. Device for Applying Pressure to Rolls.

In all gilling processes, including preparing, it is customary for the leather apron to run over the lower front roll and down under the wooden carrier roll. In drawing boxes, where an apron is also used, it is usually on the upper roll with the carrier roll above it. In the former method the fallers are more visible, and may be removed much easier.

As an example of the method of finding the draft of a gill box, the draft will be calculated from the plan and side elevation shown in Fig. 90. The diameter of the bottom front and back rolls (which are the drivers) is three and one-half inches, which equals approximately eleven inches circumference; and the pitch of the screw is one and one-eighth inches, single thread.

Referring to Fig. 90, A is the back shaft on which are placed the



BACK-WASHING MACHINE FOR WASHING AND DRYING WORSTED SLIVERS

Platt Bros. & Co.

bevel gears BB of 22 teeth. These bevel gears mesh with the bevel gears CC on the screw shaft, which also have 22 teeth. DD are the top screws; E is the bottom back roll; F is the bottom front roll; and GG are the calender rolls, which take up the sliver as it is delivered by the front rolls. H is a gear of 25 teeth on the front roll shaft; JJ are two intermediate gears; and K is a gear of 15 teeth on one end of the back shaft A. On the other end of the back shaft, there is a gear L, of 24 teeth, which drives the inside stud gear of 75 teeth; which in turn gives motion to the gears N, O, and P of 18 80 and 25 teeth

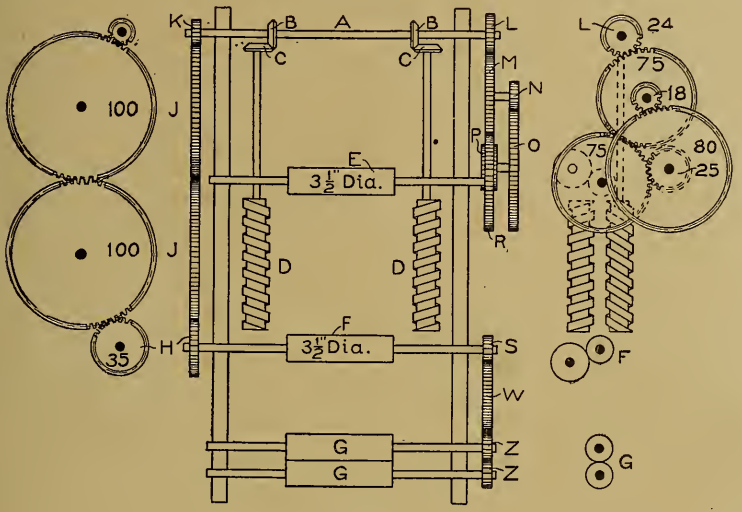


Fig 90. Plan of Gill Box.

respectively The gear P is directly underneath the gear R, of 75 teeth, which is on the back roll shaft. The gear S on the front roll shaft drives the calender rolls through the gears W, Z, and Z.

Thus it will be evident that the screws are driven by the bevel gears BB meshing with the bevel gears CC. The front roll F is driven by the gear K, which is on the back shaft A, through the intermediate gears JJ and the gear H on the end of the front roll shaft. The back roll E is driven from the back shaft A by the gear L through the stud gears.

To find the front draft: Multiply the circumference of the bottom roll (11) by the number of teeth in the gear K (15) and the bevel gear C (22), and divide the product by the number of teeth in the gear H

(35), multiplied by the number of teeth in the bevel gear B (22) and the pitch of the screw ($1\frac{1}{8}$).

$$\frac{11 \times 15 \times 22}{35 \times 22 \times 1\frac{1}{8}} = 4\frac{4}{21}$$

Therefore, the front draft is a little more than $4\frac{1}{6}$.

To find the back draft: Multiply the pitch of the screw ($1\frac{1}{8}$), bevel gear B (22), stud gear M (75), stud gear O (80), and gear R on back roll shaft (75) together, and divide by the bevel gear C (22),

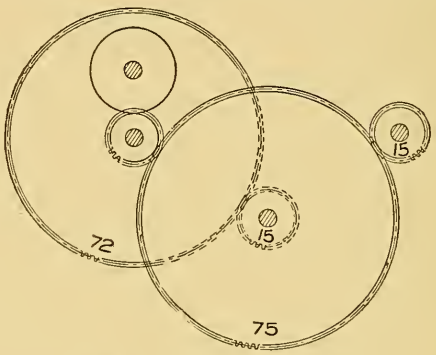


Fig. 91. Double Stud Gearing.

stud gears N and P (18 & 25), circumference of back roll E (11), and gear L (24).

$$\frac{1\frac{1}{8} \times 22 \times 75 \times 80 \times 75}{22 \times 18 \times 25 \times 11 \times 24} = 4\frac{2}{2}\frac{2}{2}.$$

To find the total draft: Multiply the front and back drafts together. $4\frac{4}{21} \times 4\frac{2}{2}\frac{2}{2} = 17\frac{1}{7}$.

The drafts for all gill boxes are found in the same manner; the only difference being in the different sizes of rolls, pitch of screws, and gearing. For machines with smaller back drafts, a double stud gear, shown in Fig. 91, is used to drive the back rolls, in place of the three stud gearing shown at Fig. 89 and used in the above calculation.

BACKWASHING

The sliver doffed from the worsted card or from the preparing gill boxes, is somewhat discolored in consequence of the oil used after scouring, which makes a considerable amount of dirt adhere to the fiber. It is very desirable to remove all such impurities and

thoroughly cleanse the wool of all grease and foreign matters before reaching the gilling process. (The operation of running long staple wools through preparing gill boxes is not classed as gilling.) This is done on what is known as a backwashing machine.

TABLE 12

OUTPUT OF PREPARING BOXES

	Ozs. of wool put up per yard of feed sheet	No. of ends up	Ozs. per 10 yards	Total Draft	Ozs in 10 yards of resulting sliver
1st Sheeter....	56	—	—	36	15½
2nd "	56	—	—	36	15½
3rd Can box ..	48	—	—	16	30
4th " " ..	—	9	30	12	22½
5th " " ..	—	8	22½	10	18
6th Backwash	—	8	18	9	16

The principle of the backwasher is so simple that little explanation of the washing and drying which compose it, is necessary. The illustration shown in Fig. 92 represents a diagram of a backwashing machine.

As the process is intended to remove the impurities from the wool, there are two small bowls, marked D and E, each of which has a pair of squeeze rolls to press out the suds after immersion. The lower roll C is made of brass, while the upper roll is of iron and is tightly wrapped with wool. The amount of dirt in the wool is usually so small that only the best soap is added to the water in the bowls. As the wool is always treated in the sliver form there can be no agitation by forks or other means, therefore squeezing is the only means of removing the dirt.

The feed rolls A have the same surface speed as the squeeze rolls. They draw the sliver, which is marked W, from the cans and pass it to the submerged brass roll B, as shown in the upper bowl E. Ordinarily, no impurities are removed until the wool reaches the large squeeze rolls C, but in some cases, where the wool is unusually dirty, one pair of squeeze rolls is not considered sufficient. To increase the washing power some bowls are made with two or more small brass rolls as arranged at B, in the lower bowl D, instead of having but one immersion roll. In an arrangement of this sort it would be too much strain for the wool to pull these rolls around, so

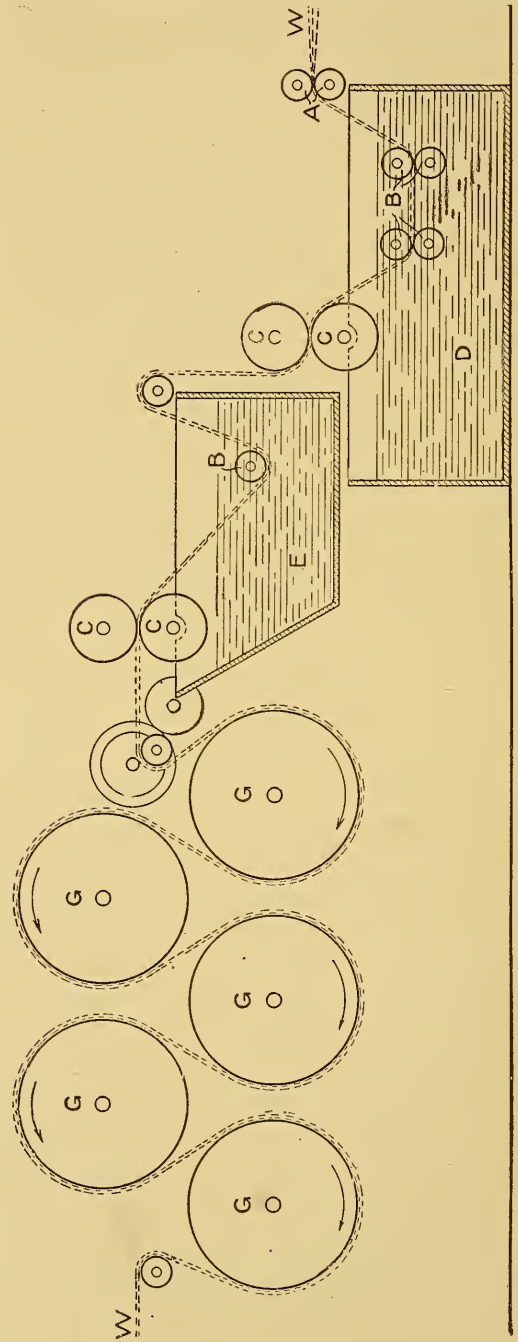
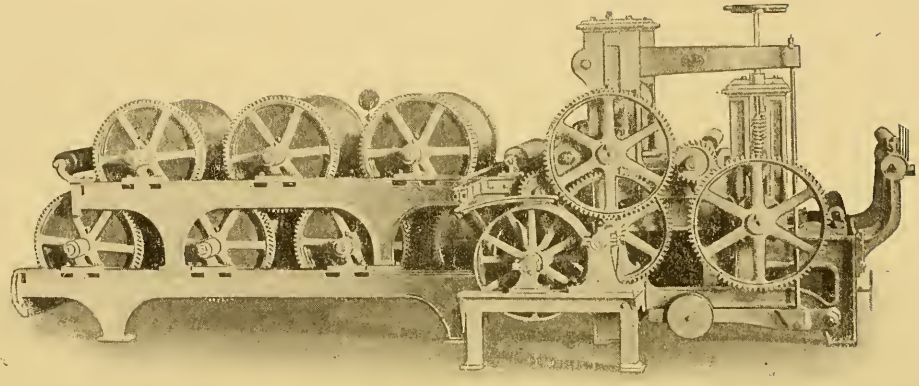


Fig. 92. Backwashing Machine and Drying Cylinders.



BACK-WASHING MACHINE FOR WORSTED SLIVERS

H. W. Butterworth & Sons Co.

the shafts of the lower rolls are extended through a hole in the side of the bowl and are driven by a chain. Pressure is applied to the top roll by dead weighting.

The marked affinity which soap has for wool is very obvious in the backwashing process. The suds in the bottom bowl should be strong enough to remove the dirt, and the top bowl should be for the purpose of rinsing the wool. When wool is run through bowls made up in this manner it is found that the lower bowl loses most of its soap, which is transferred to the upper bowl. So long as the upper bowl contains but little soap it will remove all that carried from the lower bowl by the wool, but as it gradually increases in strength, much of the soap is carried through the final squeeze rolls by the wool, if the water is not renewed. All the soap which passes the final squeeze rolls is dried on the wool by the cylinders G, and in extreme cases will affect the "handle" of the wool and tend to saponify some of the oil applied in the gill box.

The simplest way to keep the liquor in the bowls uniform, is to continuously run hot water into the upper bowl at such a speed that the soap strength and temperature will remain constant. By means of an overflow the excess of soap will flow down to the first bowl, and the occasional addition of a little soap to the lower bowl will keep it at the desired strength. The temperature of the liquor should never exceed 120°F. or some of the inherent properties of the wool will be destroyed, causing trouble in subsequent processes.

The appearance of the wool may be improved by adding coloring matters, but this does not benefit the wool in any way. Such practices are resorted to, however, by the manufacturers of "tops" or balls of wool. There are undoubtedly instances where the over-use of cleansing agents and too high temperature in an effort to give the wool the best possible "color" has very materially reduced the value of the wool.

Drying. From the last pair of squeeze rolls the wool goes to the cylinders G to be dried.

The cylinders are arranged in such a manner that first the upper and then the under side of the sliver is in contact with the cylinders. This is shown in Fig 92. Some backwashing machines are equipped with a fan which drives the hot air through the slivers. This is very useful when thick slivers are being handled. When a

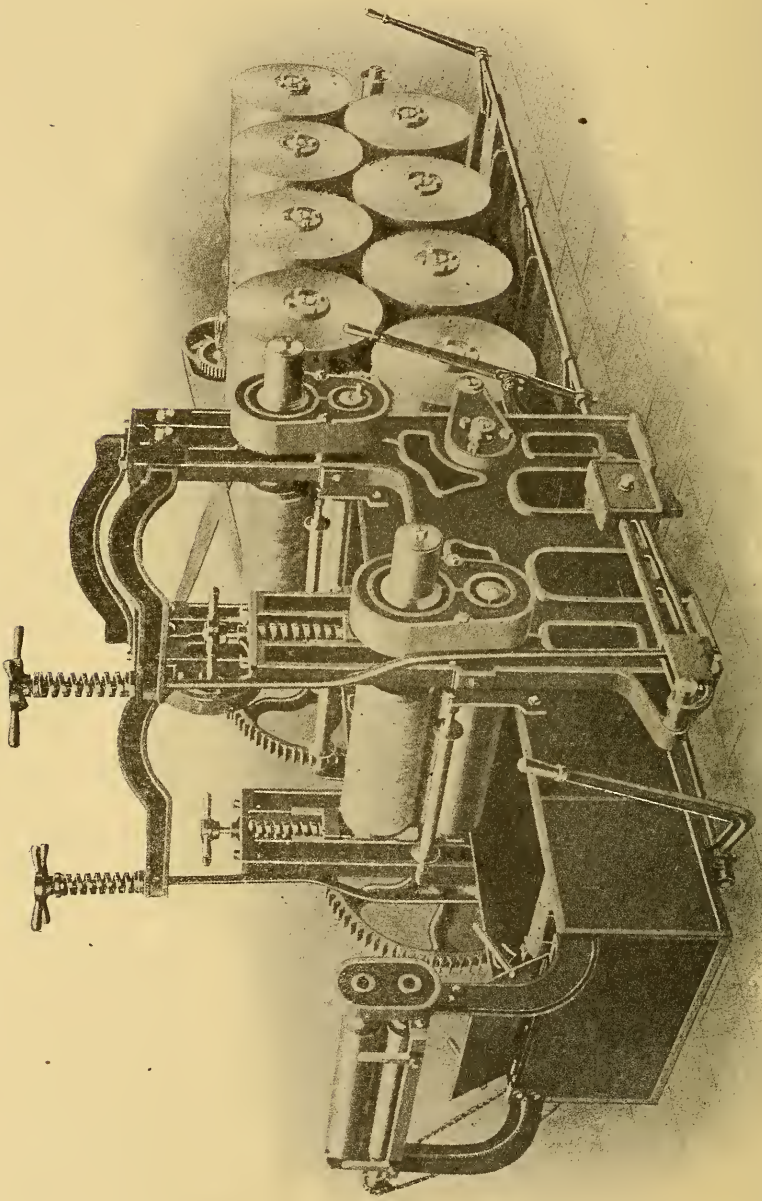


Fig. 93. Backwashing Machine.

fan is used the cylinders are enclosed, which assists in drying the wool with as little heat as possible, so for this reason the use of a fan and enclosed cylinders is an excellent arrangement.

Oiling. As the wool leaves the cylinders of the dryer, oil is again applied; the quantity being regulated according to the requirements of the wool. It is necessary to have the oil applied evenly and constantly while the machine is in motion, and to stop when the machine is stopped. One of the simplest and best devices is to have a tin roll revolving in a trough of oil as shown in Fig. 94. As the roll A revolves, a thin film of oil is brought up on its surface, which is scraped off by a number of strips of tin B, which are hinged on a wire, and one end of which rests on the surface of the roll A. The oil is thus transferred to this strip of tin or conductor, as it is sometimes called, and drops on to the wool. The amount of oil used can be regulated by increasing or decreasing the number of conductors.

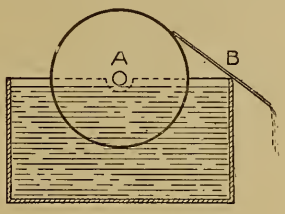


Fig. 94.

After leaving the cylinders the wool passes through a gill box attached to the front of the backwashing machine. This gill box is similar to those described under the heading "Preparing", therefore it is unnecessary to go into detail regarding it. In Table 10 it is the sixth gill box, there being five preparing gill boxes which precede it; but for carded wools this is the first gilling process through which the wool is passed.

The shorter and finer fibers of carded wools make small front and back rolls and finer pins in the fallers necessary to hold the wool. The particulars given below are suitable for fine and medium wools.

	Back Rolls		Flutes per inch	Pitch of Screws	Fallers		Front Rolls		Drafts		
	Bottom	Top			Rows of Pins	Pin per inch	Bottom	Top	Back	Front	Total
Medium	3	3	5	$\frac{5}{8}$	2	14	3	3	$1\frac{1}{2}$	6	9
Fine	$2\frac{1}{2}$	3	5	$\frac{1}{2}$	2	15	$2\frac{1}{2}$	3	$1\frac{1}{2}$	4	6

The drafts for short fine carded wools are, of course, much smaller than for long prepared wools. There is a rule among practical men that the draft should be equal to the length of the wool, and

in most cases this is true, although long wools will sometimes stand much more draft than the length of their fibers.

As shown in Table 10, the wool is passed through two more gill boxes after the backwash gill box and before the combing operation. These operations are to open the wool thoroughly, which will prevent many of the long fibers being combed out with the short fibers or "noil."

COMBING

There are two objects to be attained in combing: *first,* to remove the short fibers present in the wool; and *second,* to lay the long fibers in parallel positions.

Gill boxes, as previously explained, produce a uniform ribbon or sliver in which the fibers are parallel, but if examined closely it will be found to contain all lengths of fibers which, of course, unfits it for utilization in worsted yarn construction. For this reason the wool is divided in the combing operation into two distinct classes; the long fibers, which would be observed in closely examining a ribbon or sliver from the gill-box, are parallelized and used to form what is called the *top,* which is later drawn out and made into worsted yarn; while the short wavy fibers, termed *noil,* are separated and used in the manufacture of woolen goods.

The worsted thread is the result of using the straightest and longest fibers contained in the wool, whatever that may be; hence, the importance of the combing operation. A large amount of gilling will form a sliver, in which all the fibers are parallel, but to form the basis of a lustrous thread with a smooth uniform surface, something more is essential. The fibers which retain their crimpy characteristics, and resist the action of the gill boxes, must be extracted, consequently one of the main functions of the combing machine may be defined as that of *separating the short and curly fibers from the long straight fibers.*

There are several classes of combing machines, but the principal makes are the *nip* motion and the *circular* motion.

LISTER OR NIP COMB

The Nip Comb represents the first principle which was perfected to the point where wool could be successfully combed by machinery; and the perfection of this machine undoubtedly exercised a great

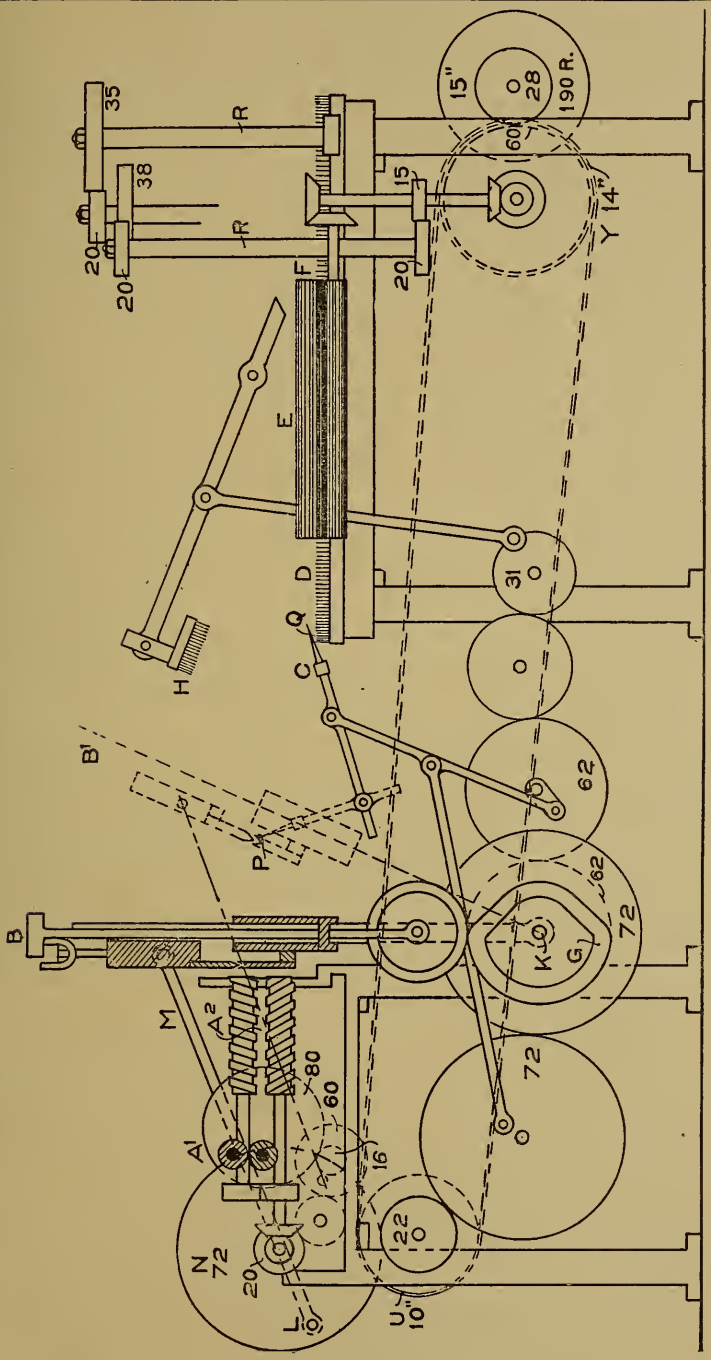


Fig. 95. Diagram of Lister Comb.

influence on the worsted industry of the world. The short, fine wools were seldom used for worsted at the time the nip comb was invented, which is, perhaps, why the skill of the inventors was directed toward the perfection of a machine to comb long wools, mohairs, alpacas, etc., which were principally in use at that time. And that is what the Lister Comb is; a *long wool comb.*

Construction. The most important parts of the machine are shown in Figs. 95 and 96. A^1 are the feed rolls; A^2 are fallers; B is the nip; C, carrying comb; D, circle; and E are the drawing off rolls.

The wool is fed into the machine from cans through the feed rolls A^1, and encounters the curved fallers A^2. It is pressed down into the

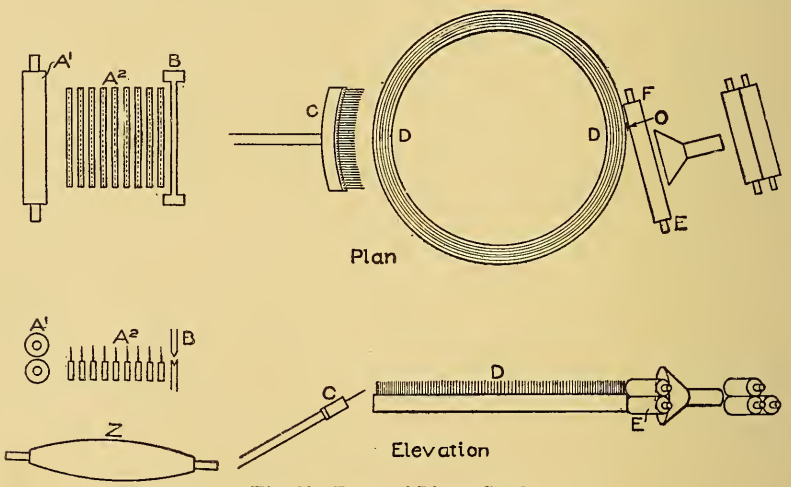


Fig. 96. Parts of Lister Comb.

pins of the fallers by a convex roll, Z, the surface of which conforms to the shape of the fallers.

There are usually twenty-eight fallers used in the machine, each having three rows of pins of eighteen, sixteen and twelve pins per inch respectively, which are set over sixteen inches. The fallers are heated by gas or steam to make the wool easier to work. The wool is carried forward by the fallers to the nip B.

Up to this point the lister comb is similar to a gill box, except that the fallers are curved, while in all gill boxes they are straight. But from this point there is a great change; for, in place of front rolls the lister comb has what is termed a *nip.*

Nip. The nip, shown in detail in Fig. 97, and B in Figs. 95 and 96. consists of a swinging frame with two jaws marked 1 and 2. It swings from the shaft K and is actuated by the cam G, which opens and closes the jaws 1 and 2. The backward and forward

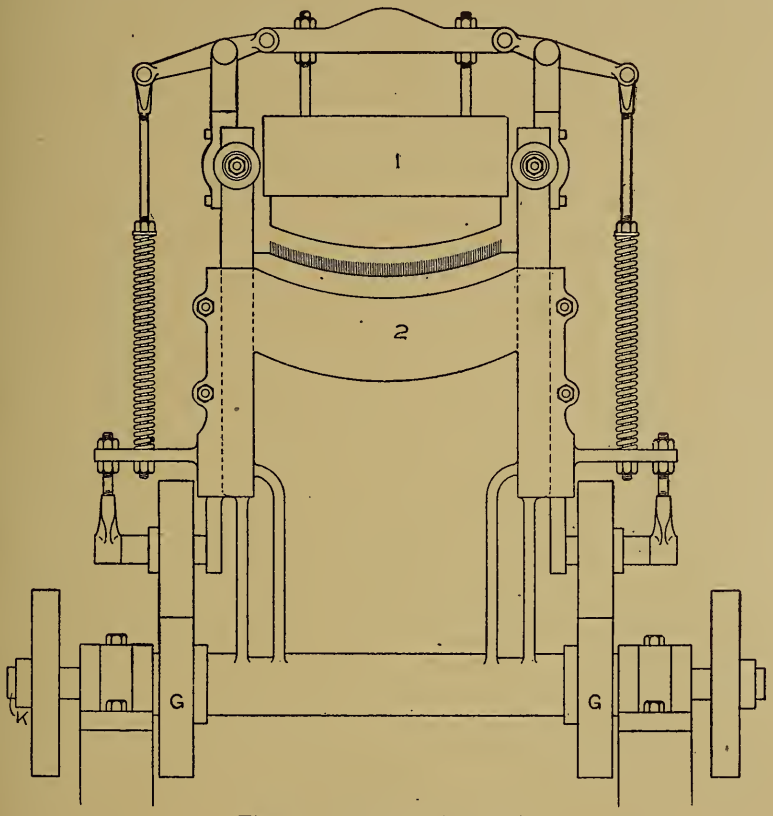


Fig. 97. Front Elevation of Nip.

motion is derived from the stud L, on the gear N, through the crank M. (Shown in Fig. 95).

In Fig. 95 the nip is shown at B, close up to the fallers, which is the farthest position backward; and at B^1 in contact with the carrying comb C, which is the farthest point forward. Between these points it has an easy swing, actuated, as stated above, by the stud L and crank M. As the nip approaches the fallers, which are full of wool, the jaws 1 and 2 open by the action of the cam G. When the nip reaches the position shown at B in Fig. 95, the jaws come quickly

together, firmly gripping the fibers of wool which project from the fallers A^2.

As will be noted by reference to Fig. 97, the upper jaw 1 has a *convex edge* which corresponds to the *concave edge* of the lower jaw. This arrangement enables the nip to hold the wool fast until it has reached the second position B^1. In moving forward, the nip draws the wool from the fallers. To this quick forward movement is due part of the combing action of the machine, for as the long fibers are drawn through the pins of the fallers, they leave behind any short wool that may be mixed with them, as the short wool does not project far enough from the pins of the fallers to be gripped by the jaws of the nip.

When the jaws close on the wool projecting from the fallers, they hold various lengths of fibers, as nothing but the shortest fibers are left behind in the fallers. When the carrying comb places the wool on the circle it follows that all the short wool or *Noil* is thrown within the outer row of pins, if not within some of the other rows, and the fringe of long fibers, which project outside of the circle pins, is straight and free from noil.

Carrying Comb. When the nip reaches its second position B^1 (Fig. 95), it is met by the carrying comb C, whose long pins slightly press against the nip at the point marked P, while at the position marked Q the long pins of the carrying comb are about to enter the long projecting pins in the center row of the circle, and deposit on them the fringe of wool just taken from the nip.

When the points of the pins in the carrying comb touch the nip at P, the carrying comb rises. and the pins run through the fringe of wool projecting from the nip. At this point the jaws open, releasing the wool, and the carrying comb moves forward, carrying on its pins the wool released by the nip. Upon reaching the position Q the peculiar motion of the carrying comb has turned it partly over so that its crescent shape (shown at Fig. 96) allows it to be in contact with the circle for its entire width.

The wool is now dabbed down into the teeth of the circle by the brush H, and the carrying comb travels back to the nip for another load. The points of the pins on the carrying comb form a crescent-like outline, like that formed by the points of the faller pins. It has two rows of pins, four inches long and set fifteen to the inch.

It will be valuable to review the description of the nip comb

given up to this point before taking up the calculations or drawing off motion. To form a clearer idea of the various parts, Figs. 95, 96, and 97 should all be referred to. A^1 are the fluted feed rolls, three inches in diameter (say eleven inches in circumference) and correspond to the back rolls or feed rolls of a gill box. A^2 are the fallers shown in Fig. 96, while in Fig. 95 only the screws are shown as this view is a side elevation. The *top screw* is $\frac{5}{8}$-inch pitch, and there are always nineteen fallers up in the top screw. Each faller has three rows of pins containing eighteen, sixteen and twelve per inch respectively. The width occupied by the pins is sixteen inches.

The *curved nip* shown in Fig. 97 is eighteen inches wide and draws the wool from the fallers. The carrying comb C is also eighteen inches wide and contains fifteen pins, four inches long, to the inch.

The *comb circle* D is forty-eight inches in diameter. It has five rows of pins set over $\frac{5}{8}$-inch with one or two rows of pins two and one-half inches long to receive the wool from the carrying comb. The first row of pins is set twenty per inch; second row nineteen per inch; third and fourth rows fifteen per inch; and, fifth row fourteen pins per inch.

The *drawing off rolls* are marked E. They are two horizontal rolls, which, as the circle D revolves, catch the fringe of long stapled wool which projects from the outside row of pins of the circle. The ends of the fibers hang too low to be caught by the drawing off rolls, so just before the fibers reach the rolls they are gently raised up by the air pressure from a small fan, or by a mechanical stroker which guides the ends of the fibers into the nip of the rolls.

This method of drawing off the wool from the circle requires special attention. The long and short fibers which compose the wool in the circle have the root end deep in the rows of pins and as they reach the rolls, which are horizontal (see E, Fig. 96) and set at a tangent to the circle, the tips of the longest fibers are the first to be drawn out, and as the circle continues to revolve the medium fibers are drawn off near the point F, where the rolls come in close contact with the circles. The noil or shortest fibers are removed from the circle by steel knives set between the rows of pins.

There is a *cutting knife* set between the drawing off rolls and circle at the end marked F. This knife, which is marked O, is to prevent any straggling fibers of noil from being drawn out after they

have passed the outer edge of the apron, and should receive careful attention. If the knife is set too far forward there will be an unnecessarily heavy noil and less sliver or *top,* and if set too far back there is danger of too short fibers getting into the sliver.

Calculations. The gearing is shown at Fig. 95. The rack is inside the circle which complicates the drive and makes necessary the use of two upright shafts RR, and the train of gears connected with them. With pulleys running at a speed of 190 revolutions per minute the *speed of the circle* would be approximately one revolution per minute.

$$\frac{190 \times 28 \times 15 \times 20 \times 20 \times 17}{60 \times 20 \times 38 \times 35 \times 347} = \frac{340}{347}$$

The diameter of the circle being forty-eight inches the actual speed of the circle would be:

$$48 \times 3\tfrac{1}{7} \times \frac{340}{347}$$

which equals approximately 148 inches per minute.

The fallers, nip, and carrying comb are all geared together by equal sized gears so that their motion is positive and they all move in unison. They are driven by a belt from the pulley Y, of fourteen inches diameter, to the pulley U which is ten inches in diameter.

To find the number of fallers dropped, and oscillations of nip and carrying comb, per minute:

$$\frac{190 \times 28 \times 14 \times 22}{60 \times 10 \times 72} = \frac{10241}{270}$$

which equals approximately 38.

As the pitch of the top screw is $\frac{5}{8}$-inch the speed at which the fallers travel would be $38 \times \frac{5}{8}$ which equals approximately twenty-four inches per minute.

The amount of wool passing through the feed rolls would be:

$$\frac{10241 \times 20 \times 13 \times 11^*}{270 \times 60 \times 80} = 22\tfrac{6}{10} \text{ inches per minute.}$$

So it will be seen that there is practically no draft between the back rolls and the fallers.

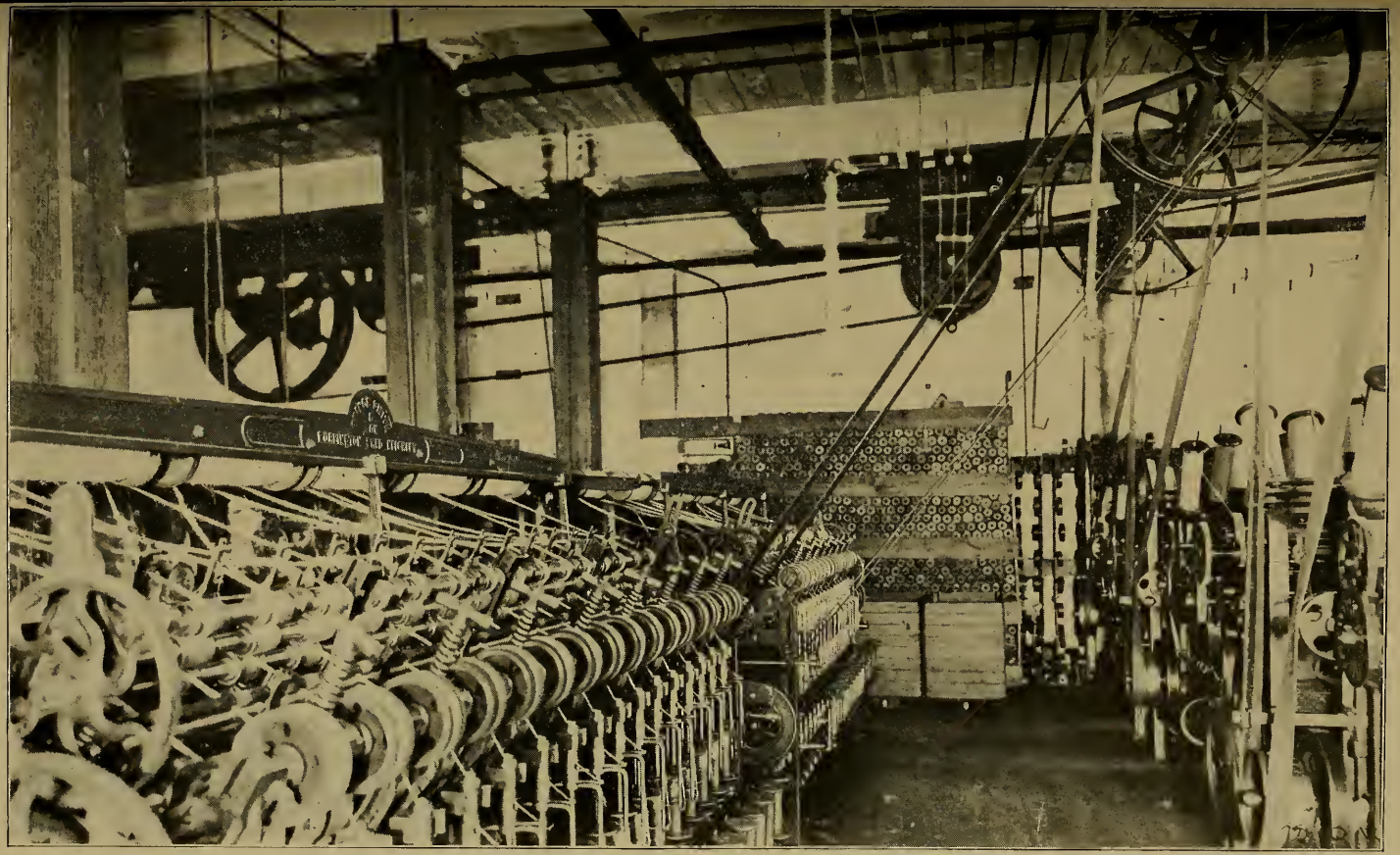
The output of the front or drawing off rolls E would be:

$$\frac{190 \times 28 \times 6\tfrac{2}{7}}{60} = 557 \text{ inches per minute.}$$

which gives the comb a draft of $24\tfrac{7}{11}$

$$557 \div 22\tfrac{6}{10} = 24\tfrac{7}{11}$$

Note: Circumference of fluted feed rolls.



30 H. P. INDUCTION MOTOR DRIVING WORSTED ROVING FRAMES
M. J. Whittall Co.

The above calculations show that the circle makes approximately one revolution per minute, which gives a surface traverse of one hundred forty-eight inches per minute to the pins of the circle; while the nip and carrying comb will deliver to the circle thirty-eight fringes of wool, each sixteen inches wide, per minute. Each fringe of wool delivered to the circle will overlap the previous one twelve inches, so there will be four deliveries from the carrying comb while the circle is moving sixteen inches, or the width of the carrying comb. By this arrangement the blending power of the machine is largely increased and the sliver drawn from the circle will be more uniform than if only a single layer was deposited every sixteen inches. As four layers of wool nearly fill the pins to the points, constant dabbing by the brush H is necessary to keep the wool down in the pins.

With suitable wool this comb will do excellent work and give a large production with very little attention; furthermore, it costs very little for repair of circles and brushes. However, the Noble comb has superseded it for combing short wools, though it still holds a secure place for combing long wools, mohairs and alpacas.

NOBLE COMB

Almost from the beginning of combing by machinery, the Noble or great circle comb, shown at Fig. 98, has proved itself the most valuable, and at present is used for combing all classes of wool. However, the Lister or nip comb is perhaps a better machine for extra long wool, mohair and alpaca, as stated in the explanation of that machine.

In general design and principle, the Noble comb has undergone no changes for more than twenty years, but in two respects it has been materially improved; the *first* and more important of these improvements was the invention of a greatly accelerated dabbing brush, which increases the productive power of the machine about twenty per cent; while the *second* and more recent improvement was the introduction of ball bearings on which the carriage of the comb revolves (see Fig. 99), effecting a great saving in the power required to operate the machine. At the present time the combs are built much stronger than formerly; the legs or supports being many times heavier on the latest machines.

Construction. The principal parts of the Noble comb are as follows:

(*a*) The large horizontal circle with rows of vertical pins.

(*b*) Two small horizontal inner circles with rows of vertical pins. (The outer row of pins on the smaller circles touches the inner row of pins on the large circle.)

(*c*) Two dabbing brushes, to drive the wool down into the pins of the large and small circles at the points where they come together.

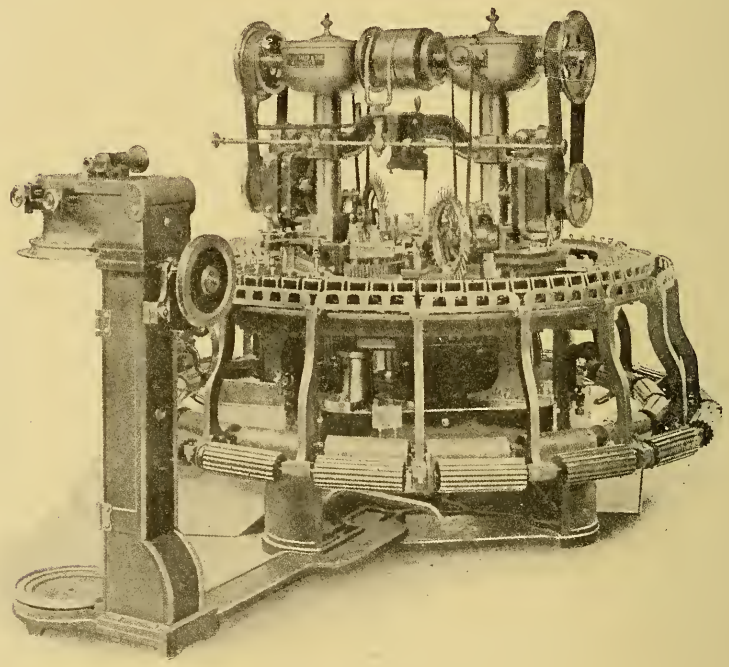


Fig. 98. Noble Comb.

(*d*) The vertical drawing-off rolls which draw away the sliver of long fibers.

The principle of the Noble comb is unique in having comb circles as the only means of clearing the wool and taking out the noil or short curly fibers. To this simplicity of principle is due the success of the machine. It also differs from all other combs in that the revolving circle carries around with it, on a creel, the wool that is being combed. The wool is made up into balls before being put in

the creel of the comb. Each ball has four ends or slivers and is wound on a machine, termed a punch box or balling machine, specially constructed for this purpose. A type of this machine is illus-

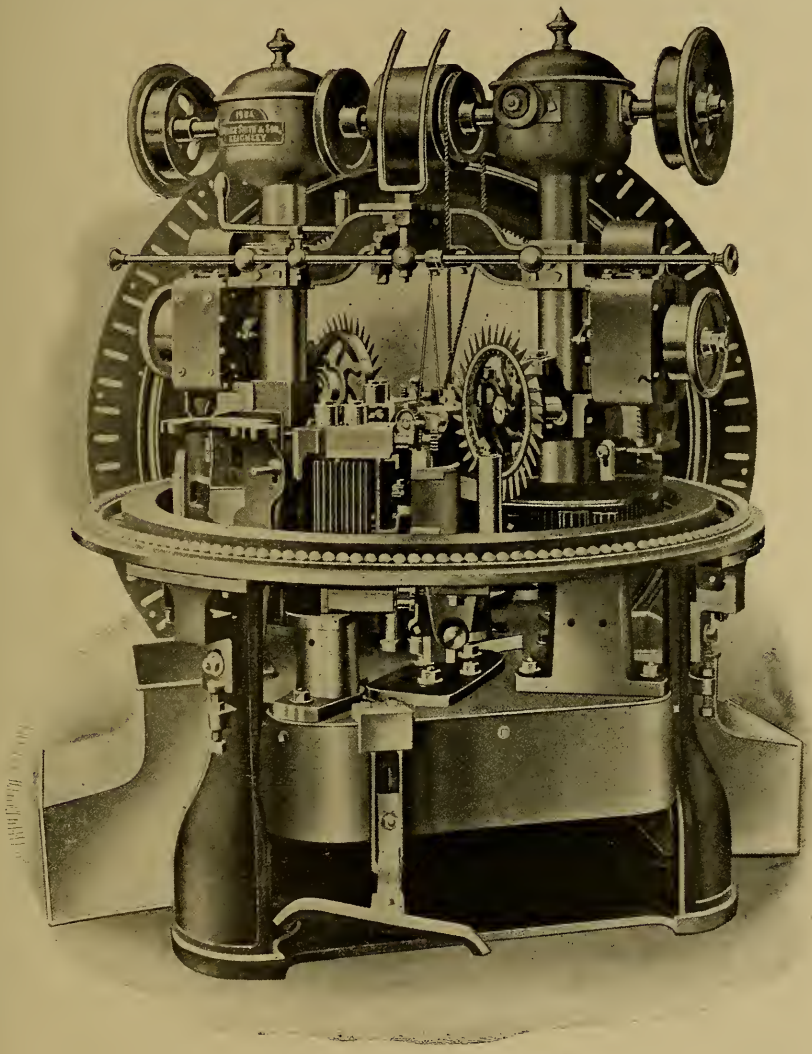


Fig. 99. Ball Bearing for Carriage.

trated at Fig. 100. The balling machine measures the length of sliver being wound into the ball, as it is necessary to have the length of sliver the same in all the balls.

As there are four slivers in each ball and eighteen balls in a set, there are seventy-two ends or slivers in a creel which are constantly being combed. This, of course, gives the machine great mixing power. The illustration, Fig. 101, shows the position of the circles which are the most important part of the machine.

The *large circle* is forty-two and seven-eighths inches in diameter, measured on the points of the inside row of pins. The diameter of the *small circles* is sixteen inches, measured on the outside rows of pins. Both the large and small circles rest on racks. The outer one has two hundred sixty-four teeth, and the inner ones have ninety-four teeth each. They are coupled together through two small

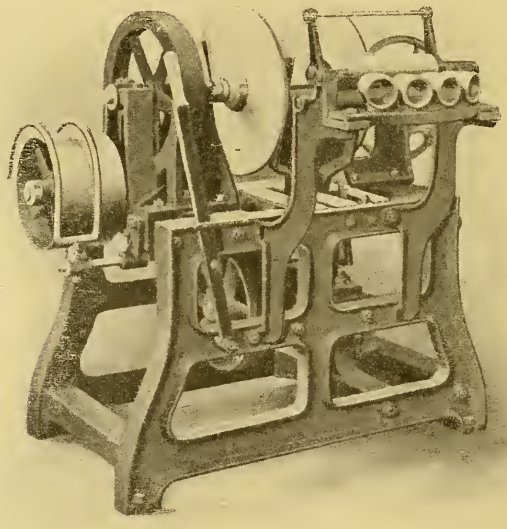


Fig. 100. Balling Machine.

shafts carrying gears of 10, 13, 16, and 11 teeth respectively, which gives the circles approximately the same surface speed. This means that at the point where the small circles come in contact with the large circle, they are practically stationary in regard to each other, and the wool can be dabbed down into both circles at one operation.

The principle of the comb lies in the fact that the surfaces of the circles draw apart as they travel around, and so the wool, which is

dabbed down into the pins of the circles when they are close together, is combed as the distance increases between the pins of the circles.

Thus it is on the separation of the circles that the efficiency of the comb depends, because all the short wool and knots are dabbed down, by the brush, into either the large or small circles. In fine circles with the pins set as close as forty-six per inch, there is a space of less than $\frac{1}{100}$ of an inch between two pins, and as no knots or vegetable matter can get through these fine spaces, the fringes of wool, which hang from both circles after their separation, are quite free from knots. From this it will be understood that it is the size of the

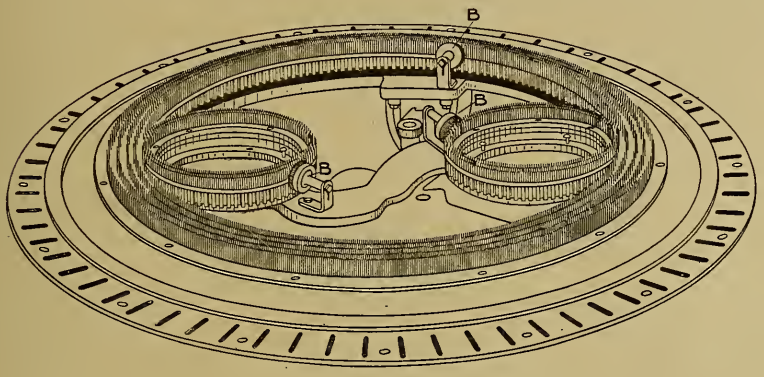


Fig. 101. Circles and Brushes.

spaces between the pins and not the number of pins per inch that is essential to secure the best combed sliver.

Referring to Fig. 102, which is a plan of the circles, it will be noted that after the large circle has traveled about one-quarter of a revolution, and the small circles have traveled nearly one-half of a revolution, the fringes of wool, which are hanging from the pins, reach the drawing off rolls N. The fibers are stroked forward so they will reach the nip of the rolls ends first, and as the circles revolve, the fibers in every succeeding portion of the fringe are drawn out of the pins by the drawing-off rolls, leaving behind all the wool that is too short to reach the nip of the rolls, and leaving within the rows of pins all knots and burrs.

There is now nothing left in the small circles but a mixture of short wool and knots, which is termed *noil*; and as the circle revolves, this is lifted out of the pins by stationary inclines or knives at M.

This is performed by having a knife between each row of pins. When the noil is raised to the top of the pins, it falls over the edge of the circle into a funnel prepared for it, and the circle is then ready to be filled again when it reaches the point of contact with the large circle.

There is only one point at which the pins of the two circles touch each other and as the sliver, pressed down into the pins at that point, is full of knots, some of the knots will be outside the pins of the circles, or rather in the space between the two circles, if the wool is dabbing on the pins at X or Y.

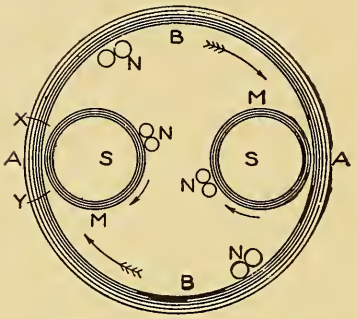


Fig. 102. Plan of Circles.

This is a point which requires careful attention, for if the wool is dabbing on the pins at any other point than A (the point of contact), a large percentage of the knots and short fibers will not be between the rows of pins of the circles, and will be drawn off by the rolls N and form part of the comb sliver. The wool must be pressed into the pins at the exact point of contact, but the dabbing brush may extend over the point X to keep the wool from raising over the points of the pins as the circles separate.

Dabbing Brushes. If the large circle, which is forty-two and seven-eighths inches in diameter between the inner row of pins, travels three and one-half revolutions per minute, the inner row of pins will move four hundred fifty-nine inches per minute, as will be shown in the calculations. With the dabbing brush mechanism running seven hundred fifty revolutions per minute the brush will strike the circles seven hundred fifty times per minute, so the circle would travel more than one-half inch for every dab of the brush. If wool were put in by the brush at one dab exactly at the point of contact, the next fibers would have traveled one-half an inch past the point of contact toward X before the brush came down again. In that one-half inch the circles would have separated slightly.

Theoretically this would be enough space for the knots to get down between the circles and make imperfect work, and it is for this reason that it is necessary for the brushes to dab rapidly. From the above it will be understood why the value of the greatly accelerated

dabbing motion was so great to those using the Noble comb. The speed at which the machine may be run, and therefore the production of the machine, is *dependent upon the speed of the dabbing brush.* The

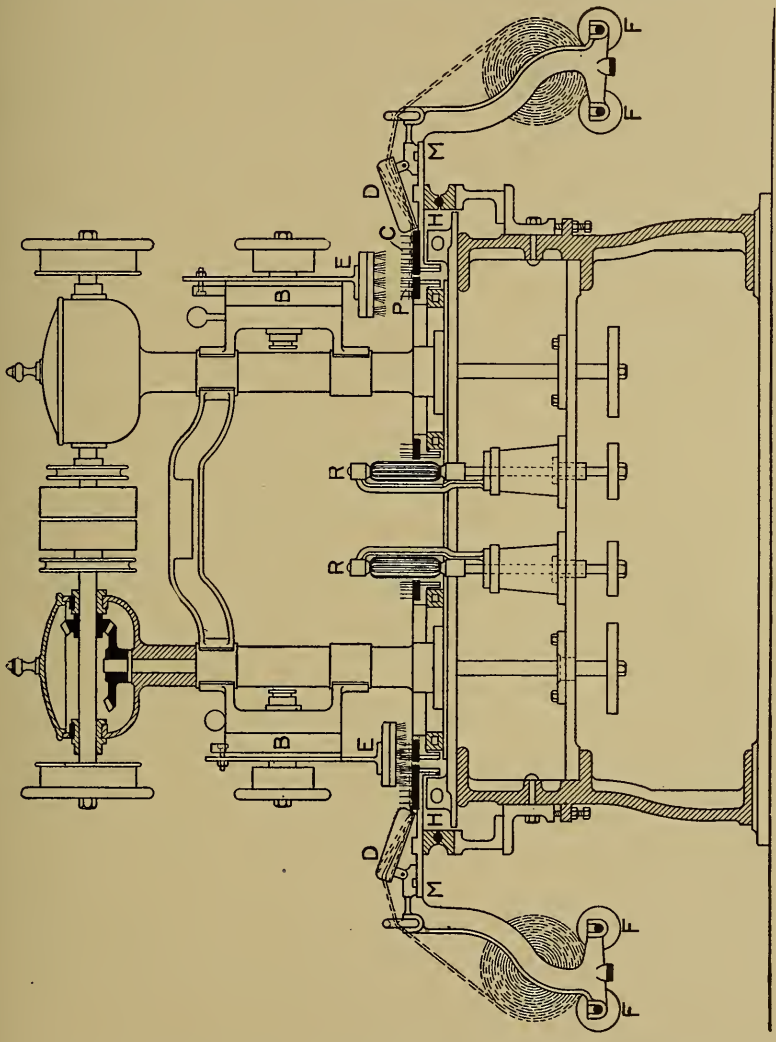


Fig. 103. Side Elevation of Noble Comb.

wear of the bristles on the dabbing brush is also decreased by the increased speed of the brush.

From the nature of the stroke imparted by the dabbing brush mechanism, the brush is in the pins of the circles for about one-quarter

of a revolution, which shows that the pins will move one-eighth of an inch through the bristles every time the brush is down. This of course cannot fail to entail enormous wear upon the brushes and the pins.

Summarizing the above it will be understood that great attention should be given to the rapid dabbing motions in order that every fiber of the wool may be pressed upon the pins within one-quarter of an inch of the point A in Fig. 102, and also that the traverse of the pins through the bristles may be as small as possible.

The first dabbing motions were operated by a single crank pin and connecting rod which may have sufficed for the slow speed at which the combs were run at the time they were first invented, but the constant demand for greater production, which means higher speed, resulted in the invention of greatly improved motions. Perhaps the latest and best motion is one where the eccentric, which drives the brush, is balanced by having another eccentric carrying the second slide, which acts as a perfect counterpoise. As the brush and its slide descend, the balance slide rises, and *vice versa*.

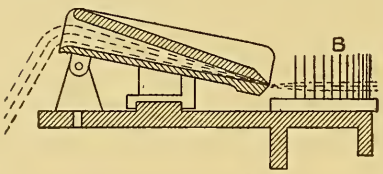


Fig. 104. Conductor.

Conductors. During one-half of a revolution or from one small circle to the other the large circle completes a number of operations which must be followed closely. To understand all these movements, it is perhaps best to commence at the beginning. The balls of wool to be combed rest on the rolls F, Fig. 103, which hang from the outer edge of the rack, and they are, therefore, carried around, without the assistance of any further mechanism, at the same speed as the large circle. At every revolution of the comb a cam moves the rolls F, and unwinds the necessary amount of sliver. The machine must then lift up the end of the sliver out of the pins, pull up the slack sliver, and lay the end over the pins of the small circle. This work is performed by the conductors D.

The conductors are a series of seventy-two brass troughs (shown in Fig. 104) fastened to the rack plate M (shown in Fig. 103). The slivers of wool pass from the balls on the racks F, each sliver passing through one of the conductors. The covers of the conductors are

hinged at the outside end so that they nip the wool at the end near the circle. This allows the sliver to be pulled forward through the circle very easily, but prevents it from slipping back. The conductor is also hinged so that the inner end can rise and fall. For the greater part of a complete revolution they are at the lowest point resting on the rack, but at a point a few inches past the drawing off rolls there is a stationary incline T, up which the conductors must rise as they travel around, while the slivers are firmly held down in the pins of the circles by the press knife P (see Fig. 105). The height or depth to which the knife is set regulates the amount of sliver drawn forward, because the conductors are always raised to the same height at every revolution.

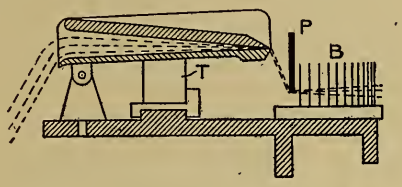


Fig. 105. Conductor and Press Knife.

Before the conductors are raised on the incline the sliver lies in the conductor and circles in practically *a straight line*, as is shown by the dotted lines in Fig. 104, but when the conductors are at the top of the incline the position is changed as is shown by the dotted lines in Fig. 105, so there is approximately one inch more sliver between the nip of the conductor covers and the pins than will reach across the pins of the large circle B.

The knives K now lift the sliver out of the pins as shown in Fig. 106, and as the conductor covers prevent the slivers from slipping back, the sliver falls forward over the steel plate which covers the pins of the large circle at this point, and whose extremity reaches beyond the pins of the small circle, which approaches the large circle at this point as shown at S. The wool is now ready to be dabbed into the pins by the dabbing brush.

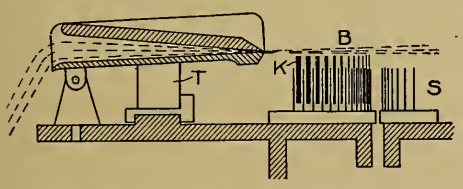


Fig. 106. Conductor with Sliver Raised Out of Pins.

As previously stated the arrangement of short and long fibers in the carded sliver does not appear to be uniform when the sliver is pulled apart, the short end having the short fibers nearer to its extremity than is the case with the long end. This peculiarity is due to the action of the doffer, and must be considered if the best results are to

be obtained in combing. To get the greatest quantity of *top* with the smallest quantity of *noil*, from any carding, the short end must be fed up first to the comb, so that when it reaches the position shown in Fig. 106 the largest quantity of short wool will be dabbed into the small circle, without having any fibers overhanging its inner row of pins. If the long end were fed up first the larger quantity of wool

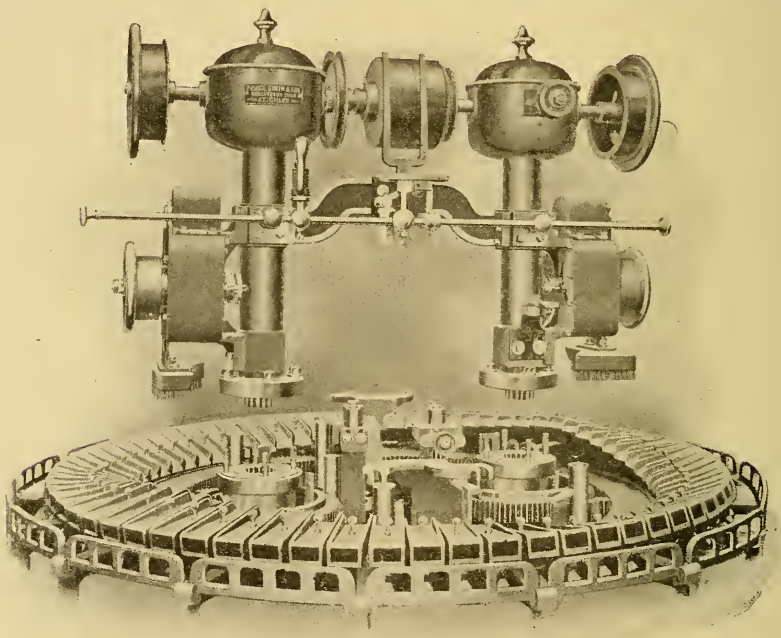


Fig. 107. Showing Conductors and Method of Driving the Carriage.

would be at least one-half inch from the end of the sliver, or in other words, when the short wool is in the pins of the small circle S, there would be a heavy fringe of longer fibers within its inner row of pins and all the longer wool would be taken off with the noil and consequently wasted.

Drawing Off Rolls. It was explained under the heading *Preparing* that fluted drawing off rolls always cut the wool unless an apron of some kind is run between them to act as a sort of cushion against which the wool is nipped. If leather aprons, which are commonly used, were durable, there would be no serious consequence to

their use, but unfortuntaely they soon wear out. This is due to two reasons: *first*, to the severe bending strain to which they are subjected every time they pass through the drawing off rolls; and *second*, to the wear caused by the action of drawing the fibers through the pins of the circle. The combined effect of drawing the long fibers from the circles and bending on the drawing off rolls always wears an apron in the middle where the greatest strain is borne. To obviate this

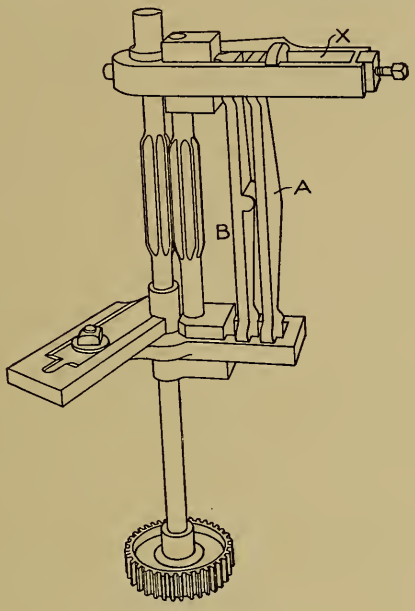


Fig. 108. Drawing-off Rolls.

effect traverse motions are used, which increase the wearing surface of the apron. This motion is driven from a shaft above the bed-plate and carries cams which raise and lower the aprons as the shaft revolves. The illustration shown in Fig. 108 shows a pair of drawing off rolls. The lever A is acted upon by a spring at X, and presses against the dog in the middle of lever B. This device equalizes the pressure on both ends of the loose roll.

Steam Chest. The steam chest in the old fashioned combs was not only the means of heating the rack, but also the only means of steadying it, and when either the rack or the steam chest was worn the rack had to be packed with brass wedges to keep it true. This, of course, wasted a great deal of power. It will be understood that

not only the rack itself, which is very heavy, has to be driven around by the gearing, but when the balls on the rolls F (shown in Fig. 103) are full, there may be three hundred pounds in addition to the weight of the creel and its fixings, so if the rack touched the steam chest, through the supporting wheels being worn, or through the accumulation of oil or any other cause, the friction would be so great as to sometimes break the driving rolls.

The essential points in a good rack motion are that it should be *true at the point of contact*; that it may be *easily driven*, regardless of the amount of weight it has to carry; and that it can be effectively *heated at the right place* without communicating heat to any point where it is not needed. The invention of ball bearings made possible the attainment of all these desirable features.

A semicircular groove is cut in a special carrying plate and filled with hard steel balls, as shown in Fig. 99, while another semicircular groove cut in the rack plate covers the upper half of the balls. The grooves and balls are cut so accurately that all lateral movement is prevented and at the same time makes the circle or rack easy to drive. The true running of the rack makes it possible to place it very near to the steam chest without any possibility of undue friction. Thus the maximum amount of heat is transmitted to the pins with very little loss.

The exact reason why wool draws better when the pins are heated has never been established, but it is undoubtedly due to the action of the heat on some of the component parts of the wool fiber.

Circles. As the circles are such an important part of combing on the Noble principle, Table 13 has been prepared to show the particulars of the circles for combing crossbred wool. The figures, such as 16 × 25, 17 × 25, and 18 × 25, in Column 3 of the particulars of the large circle, indicate the gauge size in each direction at the base (which is rectangular shape) of the first three rows of pins. Three rows of flat pins are used in both the large and small circles, as shown in the table.

The figures in Column 4 under both the large and small circle headings indicate, in decimals of an inch, the total space in every inch which is not occupied by pins, and if the figure given is divided by the number of pins per inch, the answer will be the space between every two pins. In properly arranged circles the space between the

pins steadily increases from the inside to the outside row in the large circle, and *vice versa*, or from the outside to the inside on the small circles, because the outside of the small circles and the inside of the large circle do the most combing.

There is always quite a large drop in the space between the pins, between the last row of flat pins and the first row of round pins, as may be seen in the table. This is due to the fact that the round pins are thicker and if they were not placed farther apart there would be a greater drag on the fibers.

TABLE 13

Large Circle				Small Circles			
No. of Row	Pins per inch	Size of Pins	Open Space	No. of Row	Pins per inch	Size of Pins	Open Space
			Inches				Inches
1	33	16×25	.340	1	37	16×26	.334
2	32	17×25	.360	2	36	18×26	.352
3	28	18×24	.356	3	32	18×25	.360
4	24	22	.328	4	24	22	.328
5	20	21	.360	5	18	20	.370
6	18	20	.370	6	14	18	.384
7	18	20	.370	...	...	...	...
8	14	18	.384	...	...	...	...
9	12	17	.376	...	...	...	...
10	12	17	.376	...	...	...	...

Circle Cleaning. When knots and similar particles of vegetable matter are present in the wool, they are apt to get fixed between the fine pins in the front rows of the circle, thus forcing the pins apart, and making a space through which knots and shives can pass to the combed sliver. Circles having forty-two or forty-six pins to the inch have to be made with pins so fine that they are easily bent, which of course destroys the quality for which they are made. If these fine pins are continuously cleaned, however, they produce much better work than coarser and stronger pins set farther apart. Therefore it is a good plan to employ a suitable device to remove the knots and burrs, which, if present, reduce the efficiency of the circles.

The best way to keep the circles clean is to have a brush set so that it will effectively push the knots and shives to the top of the pins, thus preventing them from becoming embedded at the base. A circular brush, shown at B in Fig. 101, with bristles parallel to its

axis, is so fixed that the upper bristles press against the pins of the circle at such an angle that the movement of the circle causes the brush to revolve. By this contact of the bristles and pins, the front row of pins is so effectually brushed that no particles of foreign matter can remain between the pins. This device is the simplest, and perhaps the most efficient, that has ever been devised for this purpose.

Framework. The peculiar manner in which the creel of the Noble comb revolves around the working parts of the machine makes

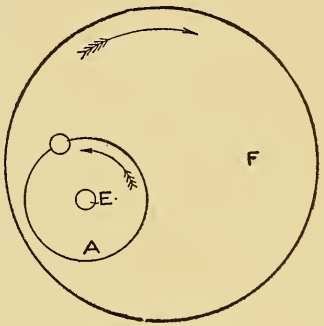


Fig. 109.

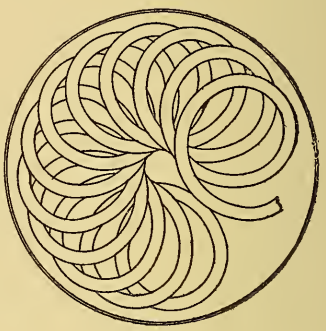


Fig. 110.

it necessary to put the driving pulleys at the top of the machine, if for no other reason, so that the operative will not be prevented, by pulleys or belts, from reaching any part of the machine at any time in its revolution. The strain of the driving shaft, being so high above the center of gravity of the machine, gives a great tendency toward vibration of the whole machine. The heavy construction of the legs and supports and the presence of a good foundation reduces the vibration to a minimum.

Can Coiler. The sliver from the drawing off rolls is passed to the can coiler device shown at Fig. 98. The object of putting the wool into a can instead of winding it into a ball is to have it in the condition from which it can most easily be drawn without any possibility of the fibers of one part of the sliver adhering to the fibers of some other part.

In all balls of wool there are some parts of the sliver where the fibers lie exactly parallel, which causes the serrations of one fiber to adhere to serrations of other fibers in other parts of the sliver. The use of a can obviates this to some extent, but if a sliver is passed into

a can which does not have a circular motion, the sliver tends to lie across the can, backwards and forwards, in layers so nearly parallel that they would not easily separate again. The can coiler is designed to overcome this condition. It is usually driven from under the comb by a shaft and bevel gears, so that the coiler will stop at exactly the same time that the comb is stopped, the sliver being so tender that it would be instantly drawn apart if the feed rolls of the coiler ran a fraction of a second after the comb stopped. It is just as important that the coiler and comb should start together and run at exactly the same speed, so, of course, a positive motion of driving the can and coiler is best.

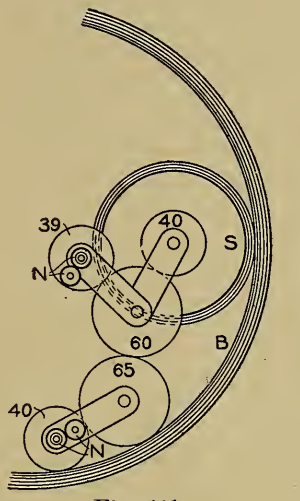


Fig. 111.

The sliver is coiled by three distinct motions: *first*, there is a rotary funnel which rolls the sliver into a rope form, giving it a sort of false twist; *second*, there is a revolving disc which receives the sliver at its center (E, Fig. 109), and as it revolves passes the sliver into the the can on the line A; and *third*, the line A is eccentric with the circumference of the can F; as the can also is revolving, the sliver is delivered into it in such a way that it lies in regular coils, similar to those shown in the illustration, Fig. 110. As will be seen by the illustration the coils of sliver do not lie in parallel positions, so it is impossible for fibers of different parts of the sliver to become entangled. The softest slivers can be drawn from cans filled in this manner without danger of breaking or injuring them in any way.

Gearing. The gearing of the Noble comb has been greatly simplified in the latest improved machines. The old style of double stud has been dispensed with and simple trains of gears, shown in Fig. 111, have taken their places. The two intermediate gears, 60 and 65, are connected by links with the gears on the drawing off roll shafts, and by this arrangement always remain correctly in gear, irrespective of how much the rolls may be moved to or from the circles. The speeds of the rolls vary to a large extent according to their size and the quality of the wool being combed. In Fig. 111,

N represents the drawing off rolls; S, one of the small circles; and B, the large circle.

Calculations. The total draft of the Noble comb can not be calculated accurately, and in fact, it is of little importance to know the draft, as the object of the machine is to thoroughly comb the noil from the long fibers and to give a large production. With the two press knives (one on each side of the machine) shown at P in Fig. 105, set to draw one inch, this distance might be considered as the feed and the output of the drawing off rollers considered the delivery, but this would not be of any value.

Assuming that the driving shaft is running at a speed of 594 revolutions per minute the following particulars may be worked out.

To find the revolutions per minute of the large circle (which of course is the same as the speed of the rack and creel): Multiply the speed of the main shaft (594), by the driving gears between the main shaft and the circle, and divide the product by the driven gears, multiplied by the number of teeth in the rack of the large circle (264).

The driving gears have 16, 20 and 10 teeth respectively, and the driven gears have 32 and 66 teeth respectively. Therefore the calculation will be as follows:

$$\frac{594 \times 16 \times 20 \times 10}{32 \times 66 \times 264}$$

which equals approximately $3\frac{1}{2}$ revolutions per minute.

To find the traverse of the large circle, the above calculation would be multiplied by the circumference ($42\frac{7}{8} \times 3\frac{1}{7}$).

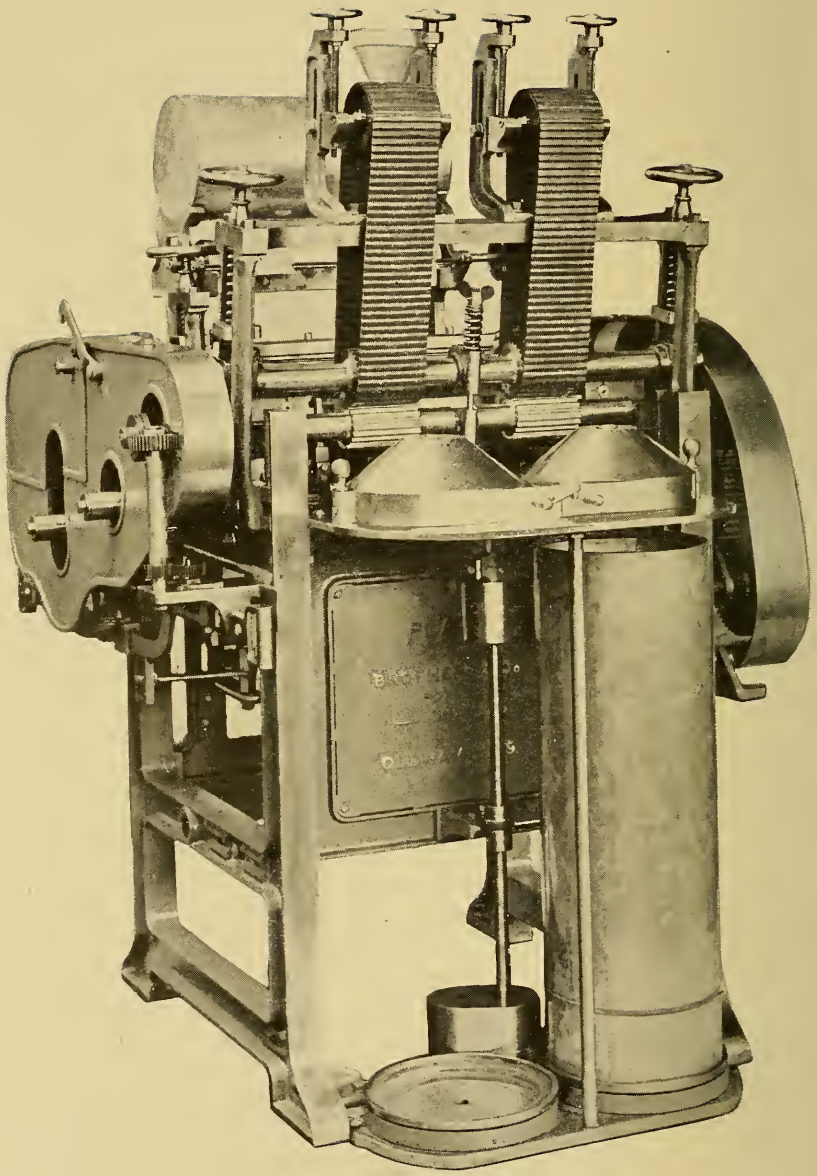
$$\frac{594 \times 16 \times 20 \times 10 \times (42\frac{7}{8} \times 3\frac{1}{7})}{32 \times 66 \times 264}$$

Which gives approximately 459 inches that the large circle traverses per minute.

To find the traverse of each of the small circles: Multiply the speed of the driving shaft (594) by the driving gears connecting the small circles and by the circumference of the small circle, and divide by the driven gears multiplied by the number of teeth in the rack of the small circle (94).

$$\frac{594 \times 16 \times 20 \times 13 \times 12 \times (16 \times 3\frac{1}{7})}{32 \times 66 \times 16 \times 94}$$

Which gives approximately 469 inches that each small circle traverses per minute.



DOUBLE CAN GILL BOX WITH COILER
Platt Bros. & Co.

To find the speed of the dabbing brushes: Multiply the speed of the main shaft (594) by diameter of the pulley on its ends (15), and divide by the diameter of the pulley on the dabbing motion (9).

$$\frac{594 \times 15}{9}$$

Which gives 990 strokes of the brush per minute.

To find the output of the drawing off rolls (N in Fig. 111 and R in Fig. 103): Multiply the speed of the main driving shaft (594) by the speed of the driving gears and the circumference of the drawing off rolls ($1\frac{1}{4} \times 3\frac{1}{7}$), and divide by the driven gears.

$$\frac{594 \times 16 \times 40 \times (1\frac{1}{4} \times 3\frac{1}{7})}{32 \times 50}$$

Which gives the drawing off rolls an output of 933 inches per minute.

A comparison of the traverse of the large and small circles shows that the small circles travel 10 inches per minute faster than the large circle. This lead puts a slight strain on the fibers, and as the circles separate, the fibers which cling to the large circle must be drawn diagonally through the pins of the small circle. If the large circle had a slight lead there would be less strain on the fibers because they would be drawn radially through the pins of both circles.

By comparing the number of strokes of the dabbing brush with the traverse of the circles, it will be noted that the circles travel approximately $\frac{1}{2}$-inch for each stroke of the brush.

FINISHING GILLING

The sliver from the comb is run through two gill boxes before being wound into balls and taken to the drawing room. Wool is gilled after combing for a number of reasons, as follows:

(*a*) To thoroughly blend the different lengths of fibers.

(*b*) To continue the process of parallelizing the fibers.

(*c*) To apply a quantity of water so that the proportion of moisture in the wool will be uniform, and at the standard; and to make every yard of sliver weigh exactly the same.

(*d*) To wind the sliver into balls so that it will occupy the least possible space, and from which the sliver may be unwound very easily when it reaches the drawing frames.

Taking up the reason given at *a*, it is necessary, if a sliver is to be as perfect as possible, that the various lengths of fibers should be intermixed as much as possible throughout every portion of the

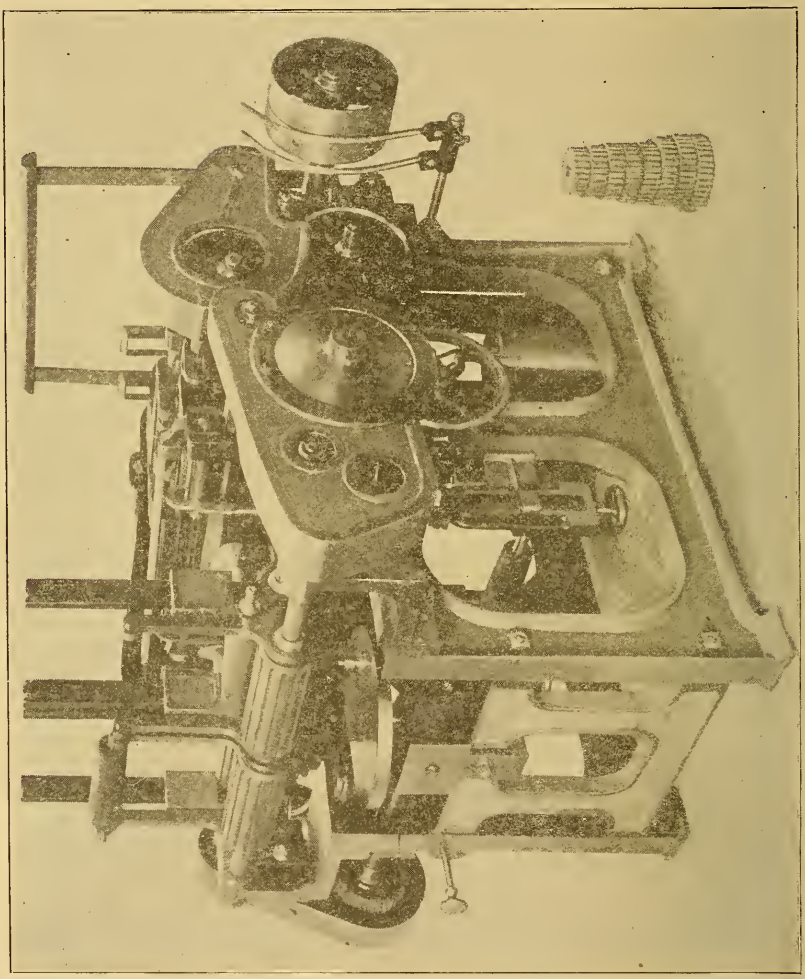


Fig. 112. Finishing Gill Box.

sliver. As no combing machine distributes the long and short fibers equally throughout the sliver, two fine gill boxes are always used to obtain this result.

The arrangement of the drawing off rolls on the Lister or nip comb produces a sliver in which all the long fibers are on one side and

the short fibers are on the other. The sliver from the Noble comb is better blended, but it is composed of four smaller slivers drawn from the four sets of drawing off rolls. The wool from the drawing off rolls on the small circles is shorter than that from the large circles, so, of course, the gilling operation is necessary to equalize the length of fibers in all parts of the sliver.

The first of the two gill boxes in the finishing process is a *can gill box*, that is, it delivers the wool into a can. The fallers are three per inch for the finest grades of wool, or two per inch for *crossbred* wool, and are carried in double-thread screws. For both kinds of wool the fallers have pins for ten inches of their width, and there are two rows of pins in each faller with sixteen and fifteen pins per inch respectively.

It is unnecessary to go into the details of the finishing gill boxes as they are similar in every way to those previously explained, having front and back rolls, and fallers. Twenty-eight cans of sliver from the comb are placed at the back of the first finishing gill box and the slivers are fed to the back rolls. If ten yards of each sliver weigh one and one-fourth ounces, and there is a draft of five on the box, the resulting sliver delivered by the front rolls is quite heavy, weighing about seven ounces to each ten yards. This is desirable, however, as the sliver will come from the can more easily and will be less likely to fray at the edges. Furthermore, only three of these slivers can be fed to each side of the last box, and there is less possibility of ends breaking down. A skillful operative may be able to piece up the broken ends without making a lump or any visible unevenness in the top, but a great many of the faults which are found in tops are caused on the finishing boxes. Every lump or uneven place in the top is serious as it can not be remedied in any subsequent process.

To return to the last finishing box, the three slivers, each weighing approximately seven ounces to ten yards, placed at the back of the last box, are drafted five to one which gives a finished sliver weighing four and one-fifth ounces to ten yards. These weights are suitable for the finest wools, but in working *crossbred* the slivers would be somewhat heavier. The same number of ends would be fed at the back of the boxes, but the sliver from the comb would be heavier.

To get the weight of the yarn uniform the drawing room must receive the tops of uniform weight. For this reason there is a standard

of weight set for various grades of wool, the weight increasing as the quality of the wool decreases. The standard weights in some localities are as follows:

Botany Wool 4 to 5 ozs. for 10 yards of sliver.
Crossbred Wool 6 to 7 ozs. for 10 yards of sliver.
Long Wool 8 to 9 ozs. for 10 yards of sliver.

The weight of the sliver is, of course, affected by the quantity of oil and water it holds by mechanical means, therefore it is necessary that the quantities of oil and water be accurately ascertained.

The supply of oil is regulated as shown at Fig. 94, and it is unfortunate that water cannot be regulated and applied by the same method. Water evaporates very rapidly when passing through the heated combs, and also in every other process where the wool is exposed as an open sliver to the warm, dry atmosphere of the combing room. To make up for this loss, water is applied on the last gill box immediately before the sliver is wound into balls.

The sliver, as it passes from the front rolls, runs over a brass roll which revolves very slowly in a trough of water. The water is always maintained at the same level and the amount applied to the wool is regulated by changing the speed of the brass roll. If the roll revolves at a high speed it would carry a large amount of water on its surface and the broad dry sliver might absorb as much as 30% of its own weight. If the brass roll revolves slowly, the water runs down the surface of the roll before it reaches the point where the sliver touches it. The speed of the roll should be regulated to add enough water to the sliver to put it in what is termed the *standard condition*; *i. e.*, the ball should contain $81\frac{2}{3}$ % of pure wool, $2\frac{1}{3}$ % of oil, and 16% of water. The water is always uniform. In cases where the wool is combed without oil there should be 84 % of wool.

Balling Head. The balling head is perhaps the chief feature of the finishing gilling, for it is very essential that the balls or tops be properly built to prevent the edges from fraying and looping some of the fibers, which will cause slubs or thick places in the drawing process and in the yarn.

A diagrammatic view of the balling machine is shown at Fig. 113. The sliver passes from the front fluted rolls R to the rolls AA, all of which have the same surface speed. The core or spindle M, on which the wool is wound, rests on the rolls AA when it is empty, and rises

vertically and parallel as the wool is wound on it. When the machine is running the sliver winds upon M, and as the number of layers increases the spindle M rises until the required size of ball has been made, when it is taken off the rolls AA, pulled out of the ball of wool, and used to form another ball.

To build a ball by machinery two motions are necessary: *first*, a rotary motion to wind the sliver around the core or spindle M; and *second*, a transverse motion to move the sliver from one side of the ball to the other. To make this possible the relative positions of the place where the sliver is delivered from the front rolls R, and the

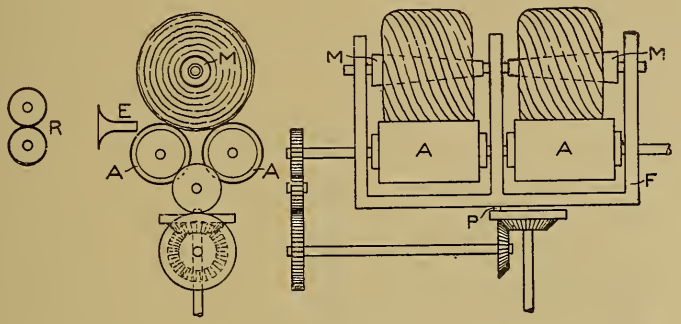


Fig. 113. Balling Head

place where it is wound on the ball, must be changed. The rolls R can not be made movable in a horizontal direction, and if a traversing conductor were put in the space between the rolls R and AA, the tension on the end of the traverse would be greater than at the middle. Therefore, the rolls AA, in addition to revolving, are made to travel about six inches across the end of the funnel or conductor E, which guides the sliver to the ball.

Each of the two horizontal shafts which carry the rolls AA has a groove running its entire length. The rolls are arranged so that they can freely slide on the shafts when moved by the frame F. Traverse motion is imparted to the frame F by the bevel gears and crank pin P. The rolls are fitted with keys which slide in the grooves or keyways of the shafts, which of course causes the rolls AA to revolve at the same speed as the shaft. The result of this device is the same as if the funnel E was traveling and the rolls had no traverse motion.

The relative surface speed of the rolls AA and the number of

traverses they make per minute is very important. If the traverse motion should make one reciprocation while the front rolls were delivering enough sliver to make one wrap around the ball, there will be many wraps side by side, resulting in a very unshapely ball, which will easily fall apart when handled.

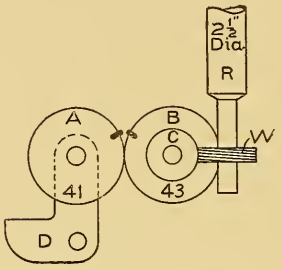


Fig. 114. Plan of Measuring.

The first wrap around the core M is seven inches long, while the outside wraps, when the ball is full, are thirty-seven inches in length. If a suitable traverse were fixed for the seven inch wrap it would be much too fast for the thirty-seven inch wrap. The traverse is generally made to suit the average wrap of about twenty-two inches. This gives about three wraps for every traverse at the core of the ball and three-fourths of a wrap for each traverse on the outside of the ball. The result of this setting is that there is always one part of the ball where the slivers never cross one another, every wrap lying parallel with the one preceding it. This, of course, causes some difficulty when unwinding the ball as the fibers of parallel wraps have a tendency to cling together making ragged edges.

A more perfect ball may be built with a traverse motion, which varies as the ball increases in size. Good results may be obtained in this line by a friction roll working on a table, but the necessity of setting such a motion every time a ball is doffed makes it rather impracticable.

Measuring. It is essential that the balls or tops off the last finishing gill box should be *uniform in weight*, and consequently in length of sliver. To get this result it is necessary to use a measuring device which will stop the machine when the proper length of sliver has been wound into the ball. The motion used for this purpose is termed a *knocker-off*; the type shown in Figs. 114 and 115 being in general use.

A five pound ball made up of sliver which weighs four ounces to ten yards will contain two hundred yards $[(5 \times 16 \times 10) \div 4 = 200]$ and the gears of the measuring motion must be arranged to give this length before stopping the machine.

Referring to Figs. 114 and 115, which show a plan and elevation

of the measuring knocker-off device, the parts are as follows: B is a gear having a number of teeth that is a prime number, such as 71, 61, 59, and 43, all of which are in practical use. A is a gear of 41 teeth which meshes with B. Both these gears have one tooth projecting beyond the others which stop the machine when they come together. If these two projecting teeth start from the point between the centers of the two gears at the same time, each gear must move a number of teeth equal to the least common multiple of the teeth of the two gears before the projections can meet again. The least common multiple of 43 and 41 is 1763, and in that number of teeth the gear B will have revolved 41 times, or the number of teeth in the gear A.

The output of the roll R, before the projections meet, will be the circumference of the roller R multiplied by the number of teeth in the gear C, which meshes with the worm W, and multiplied by the number of teeth in the gear A.

$$8 \times 22 \times 41 = 7216 \text{ inches}$$

Therefore there would be two hundred yards, sixteen inches delivered by the front roll before the knocker-off device stopped the machine.

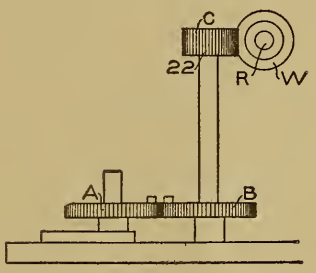


Fig. 115. Elevation of Measuring Device.

The actual operation of stopping the machine is as follows: When the projections on gears A and B come together they force the gear A and its stud plate D away from B. This releases the shipper rod from the slot in which it is held, and a spring pushes the shipper rod backward and thus moves the belt on to the loose pulley.

Top Testing. In some countries top making, *i. e.*, the manufacture of balls of wool which have been worked up to the drawing operation, is a separate industry, and to adjust the difficulties which often arise between the top maker and the manufacturers who buy wool in this form, on account of the amount of oil, water, and quality of stock, conditioning houses have been established. As the top making industry in this country is assuming large proportions, it is probable that this subject may require considerable attention in the immediate future.

When wool is combed to be sold in the form of tops, it is common practice to add an excess of either water or oil, or both, to increase the weight and thus make additional profit. Water costs practically nothing, but for every pound used the purchaser pays the same price as for the wool. Olive oil also is used and nets the top makers a handsome profit, as the cheap grade of oil used costs but a few cents per pound, while the purchaser pays the full price of the wool for it, which may be as high as 90 cents per pound.

It will be easily understood that the purchaser desires only sufficient oil to make the top work well and would be glad to buy wool which is entirely free from water. The standard adopted by the conditioning houses is six drams of oil to one pound of wool, but in some instances the parties agree upon a different basis to suit their special needs. If the amount agreed upon is exceeded, as proved by tests at the conditioning houses, the purchaser receives the equivalent in money for the excess of water and oil contained in the wool.

To find a standard for moisture is a very difficult proposition. Wool has a natural affinity for water, especially after being combed on machines which are heated by steam. In a short time after being finished they will contain from eight to twelve per cent of moisture, even when no water has been previously applied. Tops combed without the addition of moisture will rapidly gain in weight if placed in a cool moist room. This regain in weight is about the same in all qualities of tops, and averages about nineteen per cent. As is stated above, this natural regain is often increased by artificial means. The natural regain of nineteen per cent is desirable, as it improves the spinning quality of the wool, and therefore, has been adopted as a standard.

The above remarks apply to tops combed in oil, and the amount of moisture absorbed will depend upon the amount of oil in the tops. When a quantity consisting of 500 pounds of tops is tested on a basis of nineteen per cent regain, which is an exact equivalent of the sixteen per cent or standard losses, it will be found to contain only 420 pounds of wool, the remaining 80 pounds having evaporated as moisture. For instance, when 500 pounds of tops in standard condition are tested they will weigh only 420 pounds, which is a loss of sixteen per cent. The regain is figured on the dry weight of wool (420 pounds)

and the nineteen per cent of the 420, when added to the dry weight, will bring the weight back to the original amount (500 pounds).

Testing for Water. When testing for water a sample of about one-half pound is taken from each bag, accurately weighed, and then wound on a wire reel, shown at D in Fig. 116. This reel represents one end of a scale, shown at E, and is suspended with the wool in the oven F, which is kept at a temperature of about 212° F. The water contained in the wool is evaporated in 20 to 30 minutes. The scale

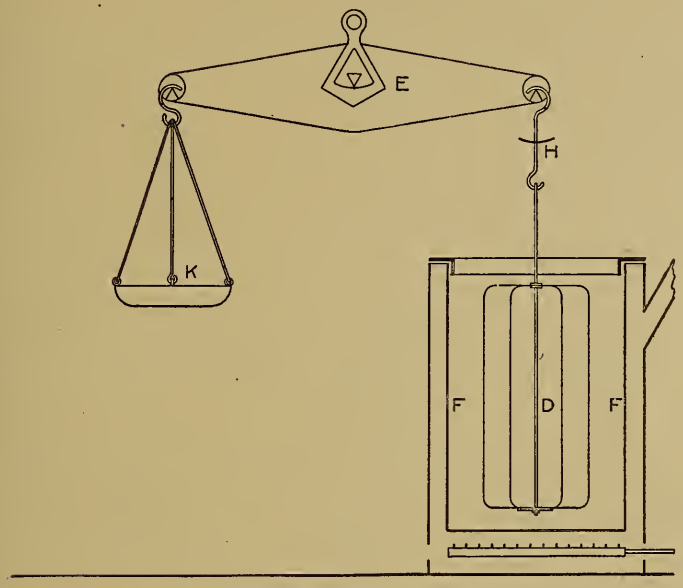


Fig. 116. Apparatus for Testing Moisture.

is then balanced, and if the samples of wool are in standard condition, the beam will balance with 2935 grains in the scale pan, K, as the wool will have lost 560 grains, or sixty per cent of the 3494 grains contained in half a pound. If half a pound of 3494 grains contains 560 grains of moisture, one pound will contain 1120 grains. This calculation is approximately correct, but of course different samples of wool will vary from the above figures.

WORSTED DRAWING

When the slivers of wool leave the last finishing gill box in the form of tops or balls, they are ready for the drawing process, which continues the operation of parallelizing the fibers and reduces the slivers to the small roving put up at the back of the spinning frame. This change is not accomplished on one machine, but is the result of what is termed a *Set of Drawing.*

There are three principal methods of drawing; *i. e., Open Drawing, Cone Drawing,* and *French Drawing.*

The principle of drawing is very simple. It is merely to reduce a thick sliver, or a number of slivers, of wool down to a sliver or roving so small that it can be spun into a thread without an excessive draft, and at the same time to even it so that the resulting spun thread will be of uniform thickness. This is done, and can only be done, by a pair of back rolls revolving slowly, and drawing the wool in, and feeding a pair of front rolls which revolve quickly and draw the wool out. This operation is repeated a sufficient number of times, with a suitable number of doublings to produce a roving of the correct weight and condition. All kinds of drawing do this, but there are differences in their methods which make them especially adapted to produce certain results.

OPEN DRAWING

A set of open drawing frames is composed of a number of machines varying from six to nine; and in extreme cases ten machines are used. The number of machines is governed by the length and quality of the wool and the weight of roving required to give the desired counts or size of yarn. For heavy roving suitable for yarn up to 20s counts, six operations are sufficient, while for medium wools suitable for 40s counts, seven and eight operations are required. For still finer wools which are to be spun to 50s or 60s counts and which, of course, require very light roving, nine operations are required.

As this is the first mention of counts of yarn the meaning will be explained. The sizes of yarns are designated by such terms as *cut, run, counts, hanks,* etc., all of which are based upon the two elementary principles of weight and length. Each term represents a certain length of yarn for a fixed weight, and *vice versa.*

In woolen manufacturing the terms cut and run are used, having

300 and 1600 respectively for their standard numbers. For instance, a one cut woolen yarn would have a hank of 300 yards to one pound; a three cut yarn would have 3×300, or 900 yards to one pound. A one run woolen yarn would have a hank of 1600 yards to one pound, or three times 1600 or 4800 yards in a three run yarn.

Worsted yarns are designated by the term counts and have 560 as a standard number. A one counts (written 1s) worsted yarn has a hank of 560 yards to one pound; a 10s worsted yarn would have 10×560 or 5600 yards to the pound; a 20s worsted would have 11,200 yards to the pound; and so on.

This makes it plain that when a certain counts of yarn is spoken of, it refers to a yarn of which the product of the number of counts multiplied by the standard number represents the number of yards which will weigh one pound. The number of yards contained in a pound increases in direct proportion as the counts increases.

The above explains why a 40s yarn requires finer roving, and consequently more machines in the drawing set than a 20s or any other coarser number.

The following table gives the machines required in a fine set of drawing machines, or in other words, a set of drawing machines for fine yarns.

1st operation—2 double head can gill boxes
2nd operation—2 double head can gill boxes
3rd operation—2 two spindle gill boxes
4th operation—2 four spindle drawing boxes
5th operation—2 six spindle weigh boxes
6th operation—2 eight spindle drawing boxes
7th operation—2 twenty-four spindle finishers
8th operation—3 thirty spindle reducers
9th operation—9 thirty spindle rovers

Operation. The following doublings and drafts would be required to make a two dram roving on the above set from a top weighing 280 drams for 40 yards.

Five slivers, each weighing 280 drams for 40 yards, would be put up at the back of the gill boxes in the first operation. With the usual draft of six, the single sliver drawn from these five slivers would weigh 233⅓ drams for 40 yards as it came from the front of the gill box. Five of these slivers, each weighing 233⅓ drams for 40 yards, would be put up at the back of each of the second gill boxes, and with the

usual draft of six the single sliver from the front would weigh 194½ drams for 40 yards.

For the third operation five slivers each weighing 194½ drams for 40 yards would be put up at the back of the third gill boxes and given a draft of six, which would give a single sliver weighing 162 drams for 40 yards. Reference to the table shows that the third operation is on spindle gill boxes, so the sliver is wound on large spools at this point.

Four of these spools would be put up at the back of the four spindle drawing box for the fourth operation, and with a draft of six, the resulting sliver would weigh 108 drams for 40 yards.

Four of these slivers would then be put up at the six spindle weigh box, and with a draft of six, the sliver would weigh 72 drams for 40 yards at the end of the fifth operation.

For the sixth operation only three slivers are put up behind the eight spindle drawing box, and with a draft of six, the sliver would be reduced to 36 drams for 40 yards.

The seventh operation takes place on what is known as the twenty-four spindle finisher; three slivers being put up and given a draft of six, which reduces the weight to 18 drams for 40 yards.

Two of these slivers are then put up behind the thirty spindle reducer, and given a draft of six, which gives a weight of six drams to 40 yards at the end of the eighth operation.

The ninth and last operation consists of putting up two six dram slivers at the back of the thirty spindle rover and giving a draft of six, which produces a roving weighing two drams for 40 yards; the desired weight.

The above set has been worked out with equal drafts, and serves to illustrate the method of reducing the large slivers from the finishing gilling to the roving required for the spinning frames. It must not be supposed, however, that the drafts used in the foregoing example are standard, for the drafts used in every operation are subject to change according to the grade and condition of the wool and the judgment of the overseer.

Before proceeding further, the reason why a set of drawing contains two machines of one kind, as in the first operation, where two double head gill boxes are used, and nine machines of one kind, as in the last operation, where nine thirty spindle roving machines are used.

It will readily be understood that the production of the machines in the first operation must be large enough to supply the machines in the second operation, so there will be no lost efficiency. It is this principle that determines the number of machines in each operation.

Another point to which particular attention should be called is the number of deliveries of each machine. For instance, both the first and second operations consist of two double head can gill boxes. As each double box is equal to two single boxes there are four slivers delivered in each of these operations.

Each of the two spindle gill boxes in the third operation delivers two slivers (one for each spindle), so there are four slivers delivered in the third operation. The fourth operation consists of two four spindle drawing boxes, so of course there are eight slivers delivered from the fourth operation.

Thus the number of slivers delivered gradually increases as the slivers are drawn out finer, until at the last operation there are nine machines, each of which delivers thirty rovings.

Medium Wools. It will have been inferred from previous statements that medium and coarse wools do not require as many drawing operations as fine wools. The following table gives the machines required in a set of drawing for medium wool.

1st operation—2 double head can gill boxes
2nd operation—2 two spindle gill boxes
3rd operation—1 four spindle drawing box
4th operation—1 six spindle weigh box
5th operation—1 eight spindle drawing box
6th operation—2 twenty-four spindle finishers
7th operation—3 thirty spindle reducers
8th operation—9 thirty spindle rovers

To make a four dram roving from a top weighing 1282 drams for 40 yards on the above set, the following doublings and drafts would be required.

For the first operation, five of these slivers, each weighing 1282 drams, would be put up at the back of the gill boxes. With a draft of seven, the resulting sliver would weigh 916 drams.

For the second operation, five of the slivers from the gill boxes would be put up at the back of the two spindle gill boxes. With a draft of seven, the resulting sliver would weigh 654 drams.

Five of these slivers would be put up at the back of the four

spindle drawing box for the third operation, and with a draft of seven, the sliver from the front rolls would weigh 467 drams.

With four of these slivers put up at the back of the six spindle weigh box, and given a draft of seven, the sliver at the end of the fourth operation would weigh 267 drams.

For the fifth operation, three of these slivers are put up at the back of the eight spindle drawing boxes. With a draft of seven, the resulting sliver will weigh $114\frac{1}{2}$ drams.

For the sixth operation, three slivers are put up at the back of the finisher and given a draft of seven, which reduces the weight to 49 drams.

Two of these slivers are put up at the back of the reducer for the seventh operation, and given a draft of seven, which reduces the weight to 14 drams.

For the last operation, two of these slivers are put up at the back of the roving machine and given a draft of seven, which makes the desired four dram roving.

A shorter method of finding the weight of roving when the weight of the sliver in the top and the number of doublings and drafts are known, is to multiply the weight of sliver by the number of doublings in each operation, and divide by the draft given in each operation. The weight of sliver from the top in the above example is 1282, and the doublings are as follows: First operation, 5; second operation, 5; third operation, 5; fourth operation, 4; fifth operation, 3; sixth operation, 3; seventh operation, 2; and eighth operation, 2. The draft for each of the eight operations is seven, so the problem is as follows:

$$\frac{1282 \times 5 \times 5 \times 5 \times 4 \times 3 \times 3 \times 2 \times 2}{7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7}$$

which gives approximately 4 drams.

Coarse Wools. For long coarse wools the following set of machines is commonly used.

1st operation—1 double head can gill box
2nd operation—1 two spindle gill box
3rd operation—1 four spindle drawing box
4th operation—1 six spindle weigh box
5th operatien—3 six spindle finishers
6th operation—4 thirty spindle rovers

If a ten dram roving were required from a top which weighed

736 drams for 40 yards, it could be obtained by the following means.

For the first operation, six slivers from tops, each weighing 736 drams for 40 yards, would be put up at the back of the double head can gill box and given a draft of nine. The resulting sliver would weigh 491 drams.

Second operation: Six slivers each weighing 491 drams put up at the two spindle gill boxes and given a draft of nine. The resulting sliver weighs 327 drams.

Third operation: Five slivers each weighing 327 drams put up at the four spindle drawing box and given a draft of nine. The resulting sliver weighs 182 drams.

Fourth operation: Five slivers each weighing 182 drams put up at the six spindle weigh box and given a draft of nine. The resulting sliver weighs 101 drams.

Fifth operation: Four slivers each weighing 101 drams put up at the six spindle finishers and given a draft of nine. The resulting sliver weighs 45 drams.

Sixth operation: Two slivers each weighing 45 drams put up at the roving frame and given a draft of nine, which gives the required roving of approximately ten drams for forty yards.

$$\frac{736 \times 6 \times 6 \times 5 \times 5 \times 4 \times 2}{9 \times 9 \times 9 \times 9 \times 9 \times 9} = 9\,\frac{97}{100}$$

In the above calculations equal drafts have been used throughout the drawing processes. This is done primarily to simplify the process of working out a set of drawing from the top to the roving, and must not be taken as a rule to work by, for equal drafts are not always convenient, and often are not advisable. For instance, a larger draft can always be used on the gill boxes than would be practicable in drawing boxes, and furthermore, the drafts and doublings must be so arranged that the machines in one operation will keep the machines in the next operation supplied with work.

Method of working out a set of drawing from the weight of 40 *yards of "Top":*

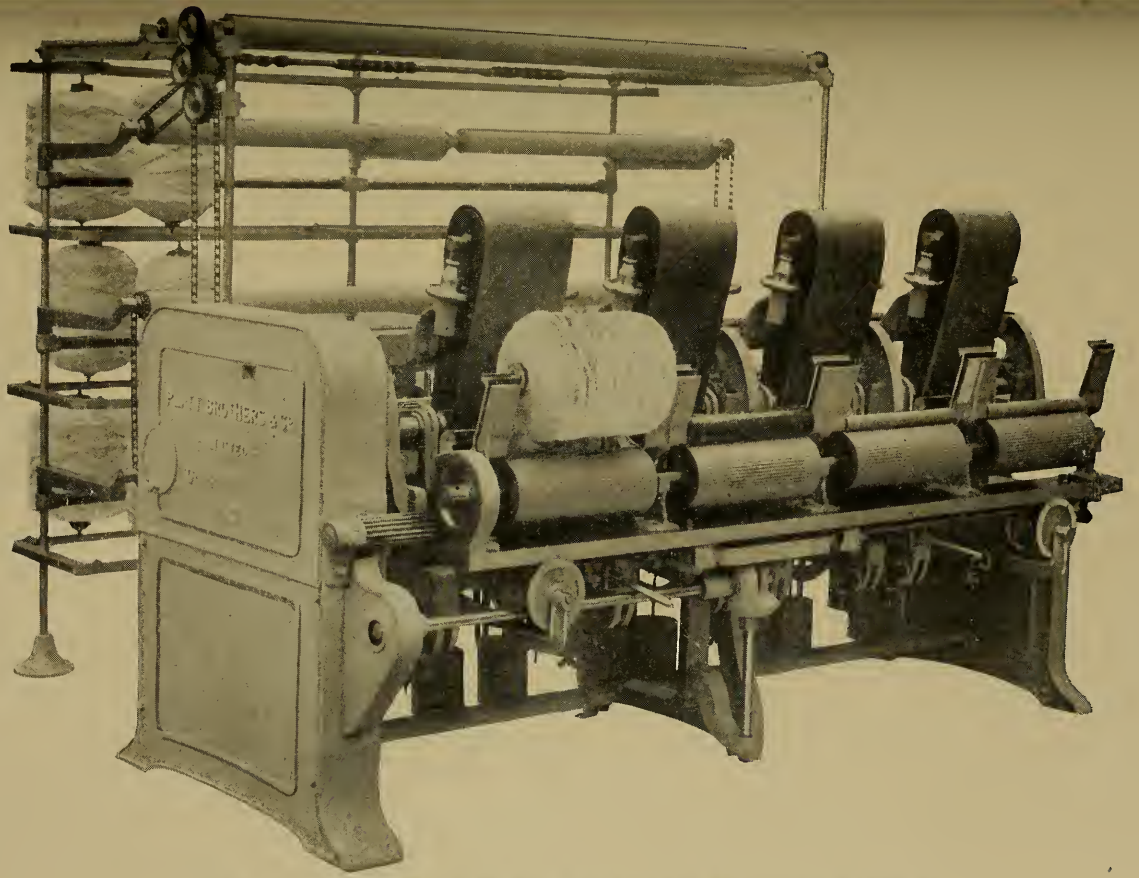
40 yards from tops weigh		280	Drams
		5	Ends up 1st gill box
	Draft 6)	1400	
		233 $\frac{2}{6}$	Drams from 1st gill box

Method of working out a set of drawing from the weight of 40 *yards of "top":*

	$233\frac{2}{6}$	
	5	Ends up 2nd gill box
Draft	6) 1167	
	$194\frac{1}{2}$	Drams from 2nd gill box
	5	Ends up 2 spindle gill box
Draft	6) 972 +	
	162	Drams from 2 spindle gill box
	4	Ends up 4 spindle drawing box
Draft	6) 648	
	108	Drams from 4 swindle drawing box
	4	Ends up 6 spindle weigh box
Draft	6) 432	
	72	Drams from six spindle weigh box
	3	Ends up 8 spindle drawing box
Draft	6) 216	
	36	Drams from 8 spindle drawing box
	3	Ends up finisher
Draft	6) 108	
	18	Drams from finisher
	2	Ends up reducer
Draft	6) 36	
	6	Drams from reducer
	2	Ends up roving
Draft	6) 12	
	2	Dram roving

If it is desired to find the weight of the sliver from the "top" to produce a certain weight of roving, the above calculations are reversed; that is, begin with the weight of roving required, multiply by the drafts and divide by the doublings, as follows:

Weight of roving required	2	Drams for 40 yards
	6	Draft on rover
Roving ends up	2) 12	
	6	Weight from reducer
	6	Draft of reducer
Reducer ends up	2) 36	
	18	Weight from finisher
	6	Draft on finisher
Finisher ends up	3) 108	
	36	Drams from 8 spindle drawing
	6	Draft on 8 spindle drawing
8 spindle drawing ends up	3) 216	
	72	Drams from 6 spindle weigh
	6	Draft on 6 spindle weigh
6 spindle weigh ends up	4) 432	
	108	Drams from 4 spindle drawing



SCREW GILL BALLING MACHINE WITH FOUR HEADS AND FOUR DELIVERIES

Platt Bros. & Co.

	108	
	6	Draft on 4 spindle drawing
4 spindle drawing ends up	4) 648	
	162	Drams from 2 spindle gill
	6	Draft on 2 spindle gill
2 spindle gill ends up	5) 972	
	194 $\frac{2}{5}$	Drams from 2nd gill
	6	Draft on 2nd gill
2nd gill ends up	5) 1166 +	
	233 $\frac{1}{5}$	Drams from 1st gill
	6	Draft of 1st gill
1st gill ends up	5) 1399	
	280	Weight of 40 yards from the top

The drafts, doublings, and weights given in these examples are not recommended for any kind of stock, but are given as examples to illustrate the method of calculation in practical use. They will be found as nearly correct as it is possible to give in general instances.

Can Gill Boxes. When commencing a set of drawing, a suitable number of ends or slivers are put up at each side or half of the first can gill box, as explained in previous examples. Fig. 117 shows a gill box of this type. The slivers pass through the back rolls, and are carried forward to the front rolls by the fallers, just as in other gilling operations. The front rolls draw out the wool into a sliver which is thinner than any of the slivers at the back, according to the amount of draft that is given. For instance, if six ends or slivers, each weighing 200 drams for 40 yards, were put up at the back (at each side), there would be 1200 drams of wool being fed to each side of the machine. With a draft of eight, the resulting sliver delivered by the front rolls would weigh 150 drams for 40 yards.

$$1200 \div 8 = 150$$

In this manner throughout the set, it is a process of doubling and drafting, continually reducing the weight of the sliver until finally the required weight of roving is obtained.

Measuring. The first can gill box is equipped with a stop motion to regulate the length of sliver put into the cans. The length of sliver is usually regulated so as to make the full cans weigh a given amount, say forty pounds. As the can weighs about twenty-two pounds, the weight of sliver in both sides of the can would be eighteen pounds. This weight however cannot be depended upon, owing to variations in the weight of the tops, and the wearing away and consequent change in thickness of the aprons. For this reason, when the cans are taken

to the second gill boxes (which are exactly like the first) a number of them, say six, are made up into a set so that their combined weight will equal 240 pounds. Such a set of six cans might weigh respec-

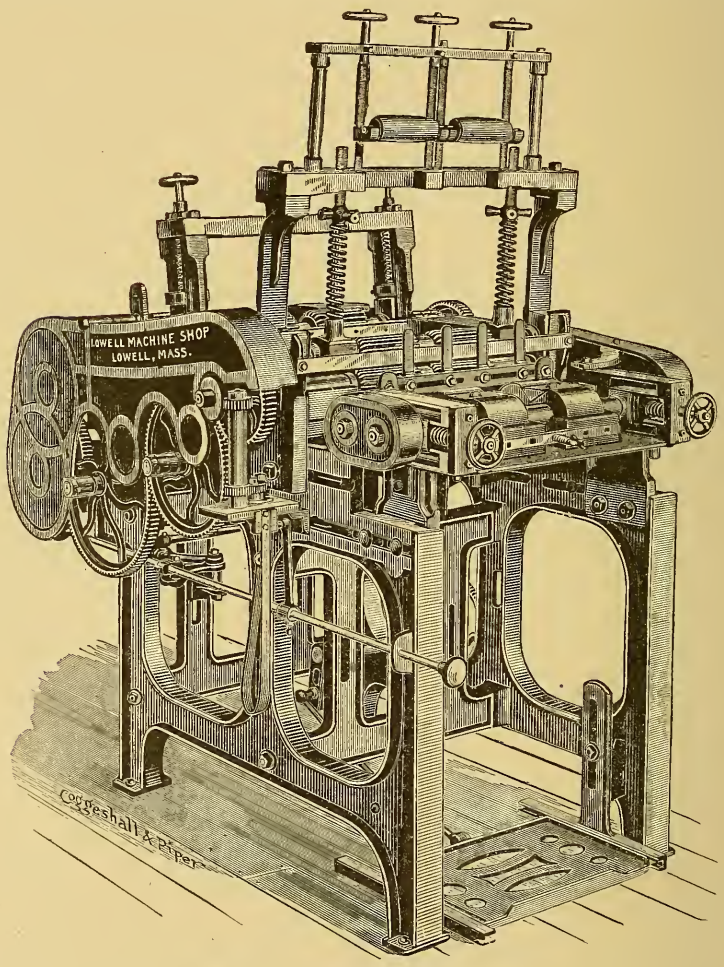


Fig. 117. Double Head Can Gill Box.

tively, 39½, 39½, 41, 39, 40, and 41 pounds, making the desired total, 240 pounds.

In some instances, a number of heavy cans accumulate, and the total weight for six cans exceeds 240 pounds. When this occurs, a larger draft gear is used on the machine to make a number of light cans to balance the heavy ones.

It is important to have the slivers uniform as early in the drawing process as possible, for it is evident that a number of slivers of exactly the same size and weight will work together better and give better results than the same number of slivers which vary in size and weight. This is especially true after the slivers receive twist at the two spindle gill boxes, and there also will be less variation in weight when the weigh box is reached.

The two spindle gill boxes are similar to the can gill boxes, with the exception that in place of cans there are two spindles on which large bobbins or spools, with nine inch heads and a traverse of fourteen

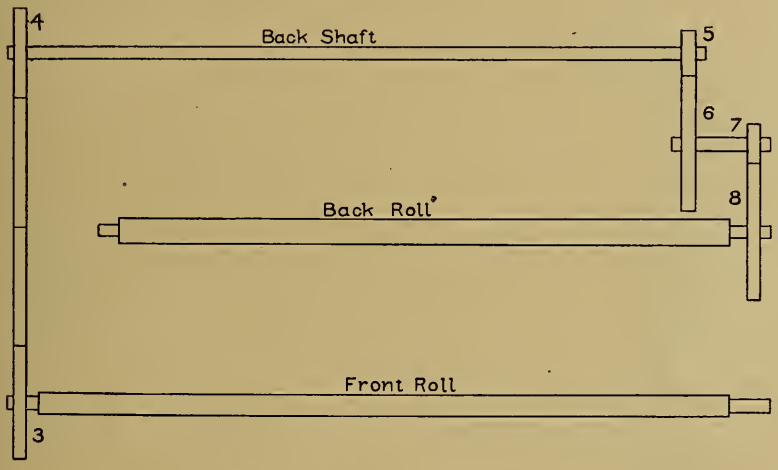


Fig. 118. Diagram of Draft Mechanism.

inches, are placed. Two large flyers attached to the top of the spindle put twist into the slivers and at the same time wind them on the bobbins.

Draft. Before taking up anything further, it will be necessary to study the draft of these gill boxes. By referring back to the explanation of *Preparing*, it will be noted that on the first preparing box the draft between the fallers and the back rolls is equal to the draft between the fallers and the front rolls, and that in each succeeding operation the draft between the back rolls and fallers decreases. In the gill boxes which constitute the first operations in drawing, there is only enough draft between the back rolls and fallers to keep the wool straight, consequently the actual draft is between the fallers and front rolls, or perhaps more correctly between the front rolls and back

rolls; with the fallers acting as a series of combs to straighten the fibers.

Regarding the parts affecting the draft, all drawing gill boxes are alike. The illustration shown in Fig. 118 is a diagram of the draft

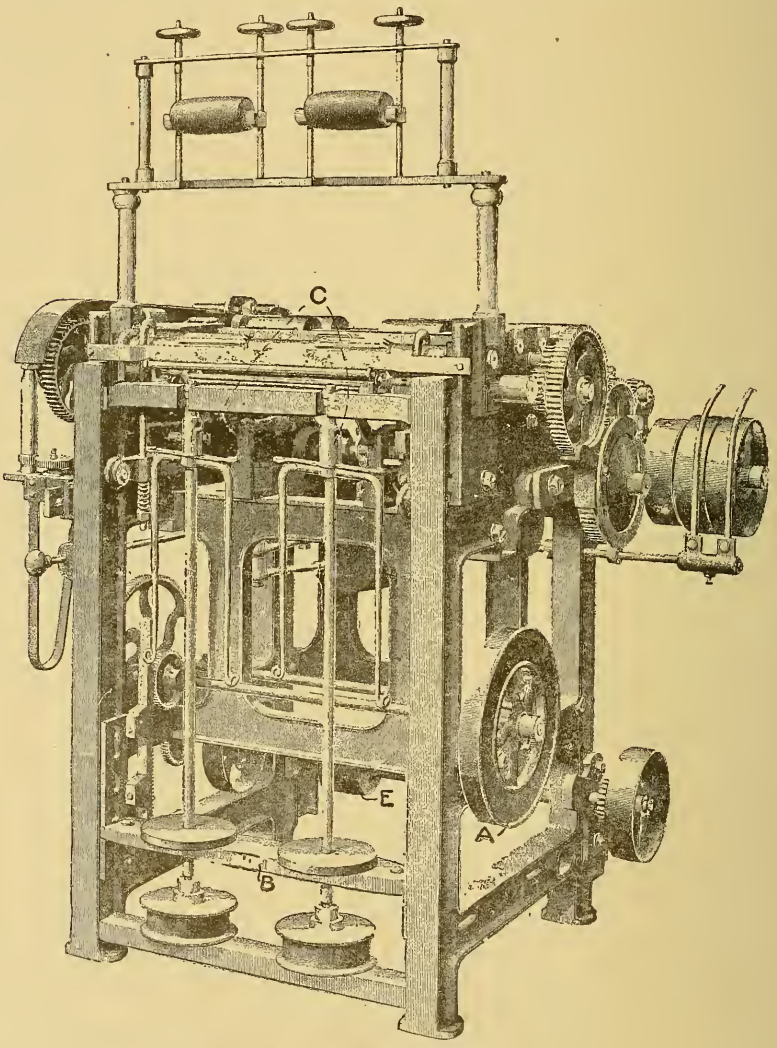


Fig. 119. Two-Spindle Gill Box.

gearing. The back roll is three inches in diameter, and the front roll is two inches in diameter. The front roll gear 3 has sixty teeth, and the draft change gear 4, on the back shaft, has forty teeth. The gear

5, on the other end of the back shaft, drives the back rolls through the stud gears 6 and 7 and may be considered a draft change gear. In this instance it has twenty teeth. The inside stud gear 6, which meshes with 5, has seventy teeth. The outside stud gear 7 is also a change gear, and in this instance has seventeen teeth. The gear 8, on the back roll shaft, has seventy teeth and is driven by the stud gear 7.

With the above particulars the calculation for the draft would be as follows: Multiply the diameter of the front roll by the number of teeth in gears 4, 5, and 8 and divide the product by the diameter of the back roll multiplied by the number of teeth in gears 3, 5, and 7.

$$\frac{2 \times 40 \times 70 \times 70}{3 \times 60 \times 20 \times 17} = 6\frac{4}{10} \text{ Draft}$$

The back roll should be set away from the front roll far enough to prevent breakage of fibers, and in the case of long wools or any wools that are hard to draw, considerable more space may be allowed.

The stop motions on the drawing gill boxes are exactly like the one shown in Figs. 114 and 115, and will not be taken up further. As previously stated, their object is to have a uniform length of sliver in the cans and on the bobbins, so that they may be weighed and made into sets.

The drawing machines or boxes follow the gill boxes. They all are constructed on the same principle, the only difference being that the flyers and bobbins are made smaller on each succeeding machine. This is necessary on account of the sliver becoming finer at each operation, for it is clear that the finer slivers could not drag around the large bobbins.

Before taking up the mechanism by which the flyers and bobbins are operated, we will become familiar with the size of bobbins and the number of spindles for each machine in one of the latest sets of drawing machinery.

Prince Smith and Sons' latest set of drawing machinery for fine wool.

1st operation—2 double head can gill boxes
2nd operation—2 two spindle gill boxes, 9 x 14 bobbin
3rd operation—1 four spindle drawing box, 9 x 14 bobbin
4th operation—1 six spindle weigh box, 8 x 14 bobbin
5th operation—1 eight spindle drawing box, 7 x 14 bobbin
6th operation—2 eight spindle 1st finisher, 6 x 12 bobbin

7th operation—2 twenty-four spindle 2nd finisher, 4½ x 9 bobbin
8th operation—3 thirty spindle reducers, 3½ x 6 bobbin
9th operation—9 thirty spindle rovers, 3 x 5 bobbin

It will be noticed that the number of spindles increases and the size of the bobbins decreases with succeeding operations. This is necessary on account of the reduction in size and weight of the slivers, which necessitates more deliveries to produce the same amount delivered by the larger and heavier deliveries of preceding machines.

The two spindle gill box, shown in Fig. 119, is the first machine in which twist is introduced into the sliver. The wool is delivered by the front rolls in the same manner as in can gill boxes, but instead of being delivered into a can it is wound on to a bobbin by means of the flyer C.

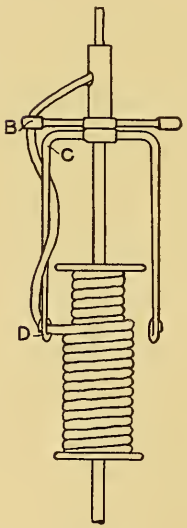


Fig. 120.
Flyer and Bobbin.

Flyers. Fig. 120 shows a flyer and bobbin. The sliver passes from the front rolls through the top of the flyer, then through a ring B at the top of the wing C. It is then wound around one of the wings and passes through the ring D to the bobbin.

The flyer fits on top of the spindle, as shown in Fig. 119, and the twist is regulated by the speed of the spindle, which is, of course, the speed of the flyer, relatively to the speed of the front rolls. The faster they deliver the sliver, the less twist can the flyers, at any given speed, put into it. The spindle is driven by a belt passing around the pulley at the bottom of the spindle, from the pulley E, which is on a shaft at the back of the machine.

The amount of twist needed for the thick sliver, or slubbing as it is sometimes called, is very small, a fraction of a turn per inch being enough.

Unlike cone drawing, where the drag is purely mechanical and consequently always the same whether the bobbin is full or empty, the sliver itself has to drag the bobbin around. The bobbins are carried up and down the length of the traverse on the builder plate B, which is controlled by the mangle wheel A (Fig. 119). The

mangle wheel operates the builder plate at the same speed all the time the bobbin is being filled. The spindles also are revolving at the same speed, therefore, it is evident that the empty barrel of the bobbin must take up as much length of slubbing or sliver as the full bobbin does. From this it will be seen that the bobbin must increase

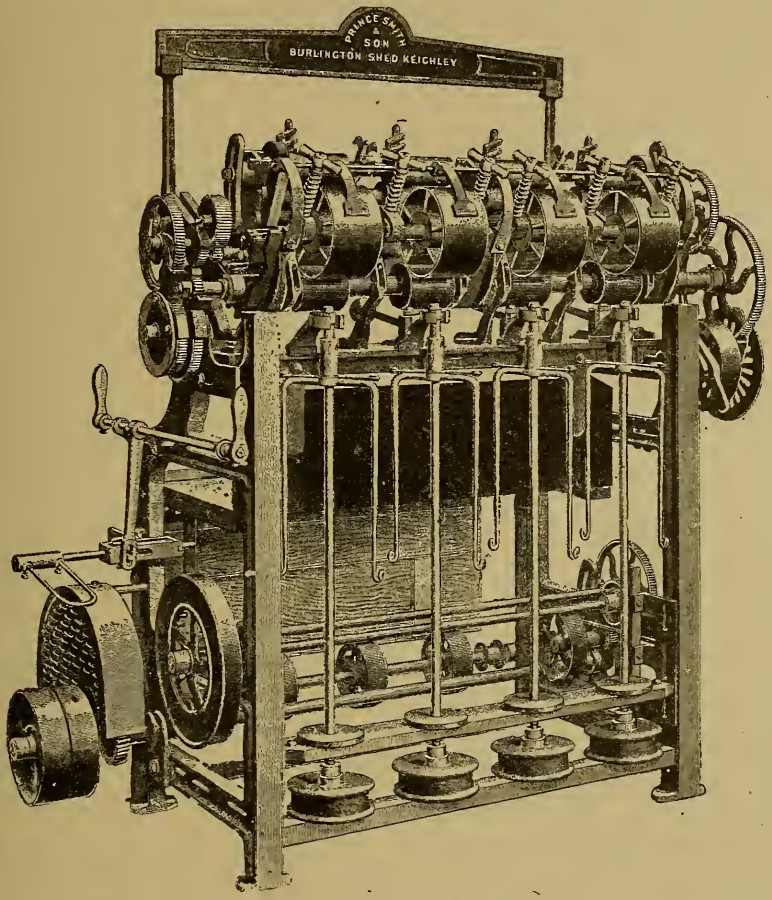


Fig. 121. Four-Spindle Drawing Box.

in speed as it increases in diameter, in order to keep up with the flyer.

On a cone drawing box the bobbin is carried around by the bobbin gear, but in open drawing the bobbin is loose on the spindle, and the drag is regulated by cloth or leather washers placed between the builder plate and the bobbin. As the bobbin increases in size and weight, the drag becomes heavier, which is a serious fault. This

is where cone drawing proves its superiority, and which is bringing it into more universal use.

The illustration, Fig. 121, shows a four spindle drawing box. The large bobbins doffed from the two spindle gill box are placed in a creel at the back of the machine, and the slivers are fed to the back rolls. There are no fallers in this machine, the operation consisting merely of the front rolls drawing out the slivers and passing them to the flyers and bobbins, as explained in connection with Fig. 119.

The weigh box follows the four spindle drawing box, and in many respects requires more care than any other machine in the set, for it is here that the final evening is done. The sliver is drawn out between the front and back rolls, the same as in the previous operation, and is wound on bobbins in the same manner.

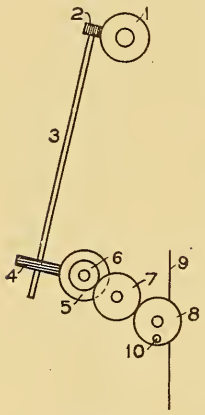


Fig. 122.

Fig. 122 shows the mechanism for measuring the sliver wound on the bobbins and stopping the machine. The worm 1 is on one end of the front roll shaft and drives the gear 2 of seventeen teeth which is at the top of the angular shaft 3. At the other end of the shaft 3 is a worm 4 which drives a gear 5 of sixty teeth. The gear 5 is on a stud with a gear 6 which is the change gear. The change gear, through the intermediate gear 7 drives the sixty tooth gear 8, which is termed the knock-off gear. Near the periphery of the gear 8 is a stud 10, which at the end of one revolution actuates the stop rod 9, which shifts the belt to the loose pulley.

To find the length of sliver delivered during one revolution of the knock-off gear: First find the constant by multiplying together the driven gears (omitting the intermediate gear 7) and 3.1416 and dividing by 36 inches. The driven gears are 2, 5, and 8, which have 17, 60, and 60 teeth, respectively.

$$\frac{17 \times 60 \times 60 \times 3.1416}{36} = 5340.72 \text{ Constant}$$

Having the constant, it is very easy to find the number of yards on each bobbin with any size change gear or front rolls. For examples assume that the change gear has 43 teeth and the diameter of the front roll is 4 inches: Multiply the diameter of the front roll by the

constant, and divide the product by the number of teeth in the change gear.

$$\frac{4 \times 5340.72}{43} = 500+ \text{ Yards}$$

The empty bobbins are balanced to weigh the same amount, therefore, full bobbins doffed from the weigh box should weigh the same. When there are differences in the weights, it is due to irregular slivers.

The full bobbins are weighed and made up into sets for the next operation. As the sliver from the weigh box has to pass through several operations before it reaches the roving machines, and if a particularly even yarn is desired, it is advisable to go through the same process of weighing and making up into sets at a later operation.

The other machines in the set are a repetition of those explained, the only difference being in the number of spindles.

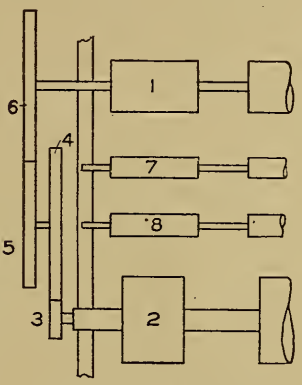


Fig. 123. Diagram of Rolls.

Drafts. The method of calculating the drafts is the same on all drawing machines, and to make it clear Fig. 123 has been prepared. 1 is the back roll $2\frac{1}{2}$ inches in diameter; 2 is the front roll 4 inches in diameter; 3 is the draft change gear, which in this case has 32 teeth; 4 is an inside stud gear of 100 teeth; 5 is the outside stud gear and has 84 teeth; and 6 is the back roll gear of 100 teeth. 7 and 8 are carrier rolls and merely support the sliver between the front and back rolls.

To find the constant: Multiply together the diameter of the front roll and the number of teeth in gears 4 and 6, and divide the product by the diameter of the back roll multiplied by the number of teeth in gear 5.

$$\frac{4 \times 100 \times 100}{2\frac{1}{2} \times 84} = 190.5 \text{ Constant}$$

To find the draft when the constant and the number of teeth in the change gear are known: Divide the constant by the number of

teeth in the change gear. With a change gear of 32 teeth the draft would be as follows:

$$190.5 \div 32 = 6 \text{ approximately}$$

To find the change gear when the constant and draft are known: Divide the constant by the draft. Reversing the above example say the draft required is 6.

$$190.5 \div 6 = 32 \text{ approximately}$$

Twist. As the slivers are so thick from the first part of the drawing, and in fact up to the roving frame, no attempt is made to figure the exact twist, all that is required being an amount sufficient to prevent the sliver from being stretched.

Ratches. Fig. 124 shows an end elevation of the rolls of a drawing frame. The length of the ratch is the distance between the nip

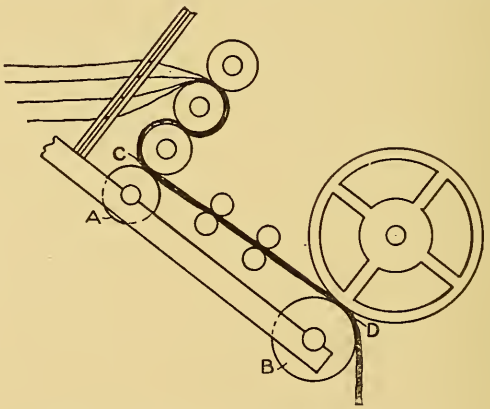


Fig. 124. End View of Rolls Showing Ratch.

of the back rolls at C and the nip of the front rolls at D. To have a sound sliver free from thick and thin places, it is important that the ratch be set correctly.

The front rolls are stationary, but the back rolls can be moved nearer to or farther from the front rolls. The wool is carefully measured and the ratch set to the length of the longest fibers. If the wool varies in length, say from 10 inches for the longest fibers to an average of 8 inches, it is an excellent plan to set the ratch on the first drawing box at ten inches and gradually bring the rolls closer together at each operation, until when the roving frame is reached the ratch should be eight inches.

CONE DRAWING

The difference between the system of drawing just described and cone drawing is merely a difference in the method of lifting the builder plate and winding the sliver on the bobbins. In open drawing the bobbin is dragged around by the sliver, the speed of the bobbin being the difference between the speed of the flyer and the length of sliver delivered by the front rolls, and wound on the bobbin. The lifter plate also moves up and down at a uniform rate of speed, irrespective of whether the bobbin is full or empty. In cone drawing these defects are overcome; the speed of the bobbin and lifter plate being regulated by the cone mechanism.

There is no doubt that cone drawing is better than open so far as results are concerned, the only difficulty being the cost of operating.

Operation. There are two ways of running the bobbins; *i. e.*, either faster or slower than the spindles and flyers. Each way has its particular merits. The bobbin leading will be taken up first.

The front rolls deliver the same quantity of sliver from beginning to end of the bobbin. As each layer is added to the bobbin it increases in diameter, therefore, each layer around the bobbin must be longer than the one preceding it, and the speed of the bobbin must be regulated accordingly. To illustrate this, take as an example a front roll four inches in diameter, which delivers sliver to a bobbin which is one inch in diameter when empty and four inches in diameter when full. It can now be seen that one layer around the full bobbin is four times as long as one layer around the empty bobbin, and consequently to maintain the same surface velocity the bobbin must travel just one-fourth as fast when full as when empty.

Any irregularity in the method of winding the sliver on the bobbin, causing some of the layers to overlap or not lie close enough, would cause too great or too little tension on the end. As has just been observed, when the bobbin is empty it must make four revolutions to wind as much sliver as would be wound by one revolution when the bobbin is full, consequently, when empty it must traverse four times as fast as when full.

The speed of the lifter and the bobbins must be decreased in the same proportion, and the change must be made at the end of each traverse of the lifter. The difference to be made at each change will depend upon the thickness of the end. This gradual change is effected

by a pair of cones working in conjunction with a *differential motion* The cones furnish the variable speed and the motion enables it to be utilized.

Differential Motion. At Fig. 125 is shown a diagrammatic drawing, with the relations of the various parts shown. A, the driving shaft, carries the driving pulley P, the gear for driving the spindles S, the bobbin gear and differential motion B, and the twist change gear T, which drives the front roll and top cone.

The differential motion is a combination of six gears, namely, a square of four gears C, D, E, and F; a crown gear G, and bobbin gear B; C being the only gear fixed to the shaft. The crown gear is loose on the shaft and works independently of it, being driven by a train of gears from the cones. It can, therefore, revolve in either

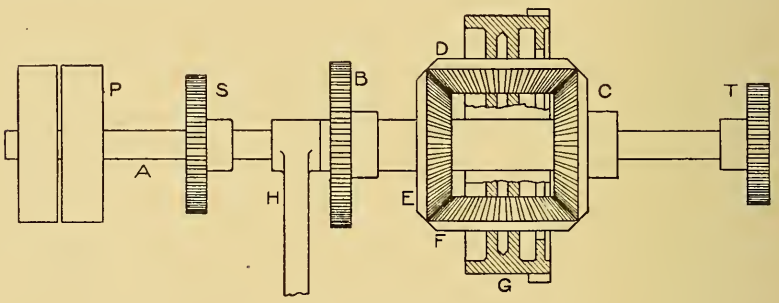
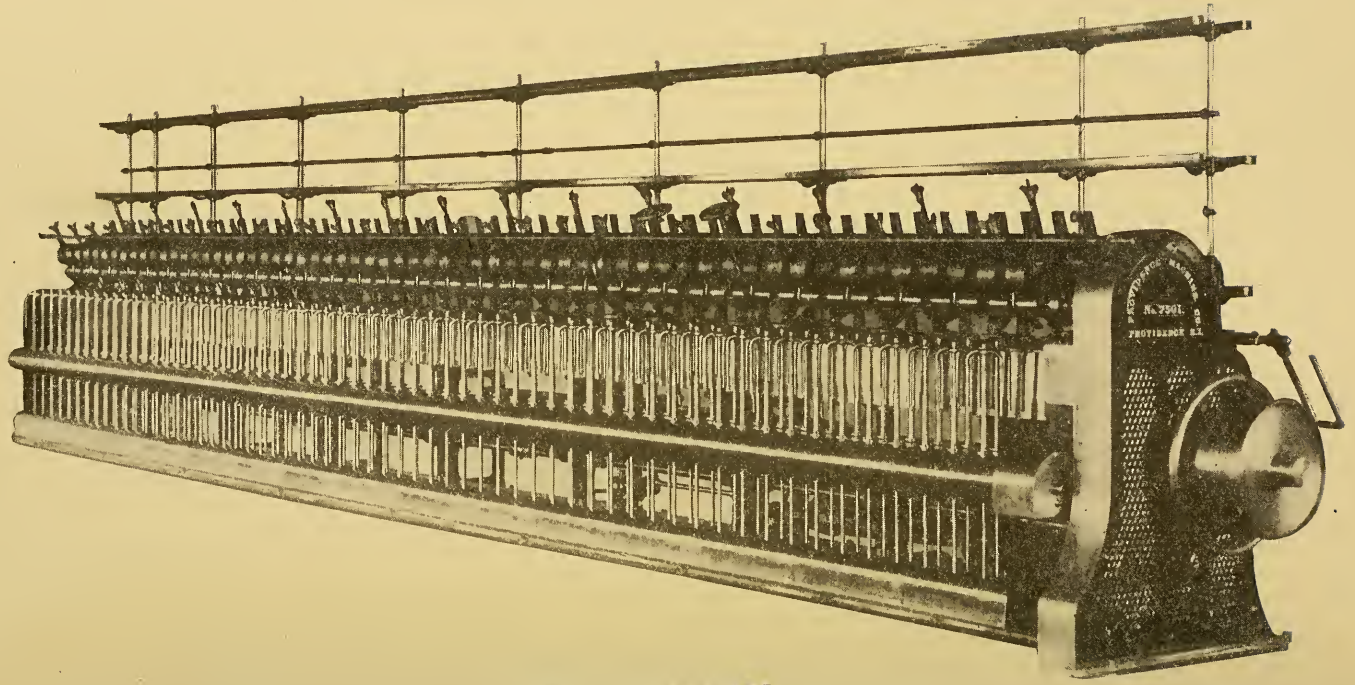


Fig. 125. Differential Motion.

direction and carry the two bevels D and F around the other two, while they act also as intermediates to convey the motion from the driving wheel C to E. The gears E and B are fastened together and run loosely on the shaft. The bobbins are driven from B. The bearing H, on one side, and the gear C on the other hold the motion in position.

If the crown gear is stationary while the driving gear C is running, E and B will run at the same speed, but in opposite directions; but if the crown gear revolves in the opposite direction to that in which the shaft revolves, it will influence the speed of E and B. For every revolution of the crown gear the bevels must make two revolutions on their own axes, and thus E receives its speed from two sources *i. e.*, the crown gear and the driving bevel C.

For example, if C makes fifty revolutions and the crown gear ten



WORSTED ROVING FRAME
Providence Machine Co.

in the opposite direction, the speed of E will be seventy, so that it receives an additional twenty revolutions. The crown gear is driven by the cones and the speed may be changed by changing the strap, which also changes the speed of the bobbin wheel. The motion may either be used for accelerated speed or for reducing the speed, which depends on whether the crown gear revolves with or contrary to the shaft.

In Fig. 126 is given a general diagrammatic view of the various parts of a cone drawing frame. The twist gear T drives a shaft L, upon which is the top cone, and at the other end a gear driving the front roll gear, by means of intermediate gears. The top cone drives the bottom cone by means of a belt. The bottom cone is mounted upon a swing shaft, which allows the belt to be adjusted when a new set of bobbins is begun.

The speed of the top cone A is constant, thus to alter the speed of B, we must traverse the belt across the cones. In Fig. 126 they are shown in the proper position for a decrease of speed; the large end of the top cone being above the small end of the bottom cone. Suppose the largest diameter of the cones is $6\frac{1}{2}$ inches, the smallest diameter $3\frac{1}{4}$ inches, that the shaft L makes 220 revolutions per minute, and that the belt is at the large end of the top cone. To find the speed of B, we would divide the diameter of the top cone by the diameter of the bottom cone where the belt touches each, and then multiply by the revolutions of L. $(6\frac{1}{2} \div 3\frac{1}{4}) \times 220 = 440$ revolutions.

Suppose the belt is at the small end of the top cone and the large end of the bottom cone. The figures are $(3\frac{1}{4} \div 6\frac{1}{2}) \times 220$ which equals 110 revolutions or just $\frac{1}{4}$ of what it is at the other end.

The speed of the bottom cone is transmitted by a train of three gears to a short horizontal shaft O, on which is a pinion E gearing into the crown gear G. Thus, as the crown gear is connected by gears to the cone, any slight variation of the cone affects the crown gear. The driving gear C and the crown gear impart their speed to the bobbin gear. Its speed will be in excess of the spindle gear S.

As an illustration of its influence, we will suppose the driving shaft is making 300 revolutions and the crown gear 20, when the bobbins are empty. This makes a total of 340 revolutions. If, when the bobbins are full, the crown wheel only makes five revolutions,

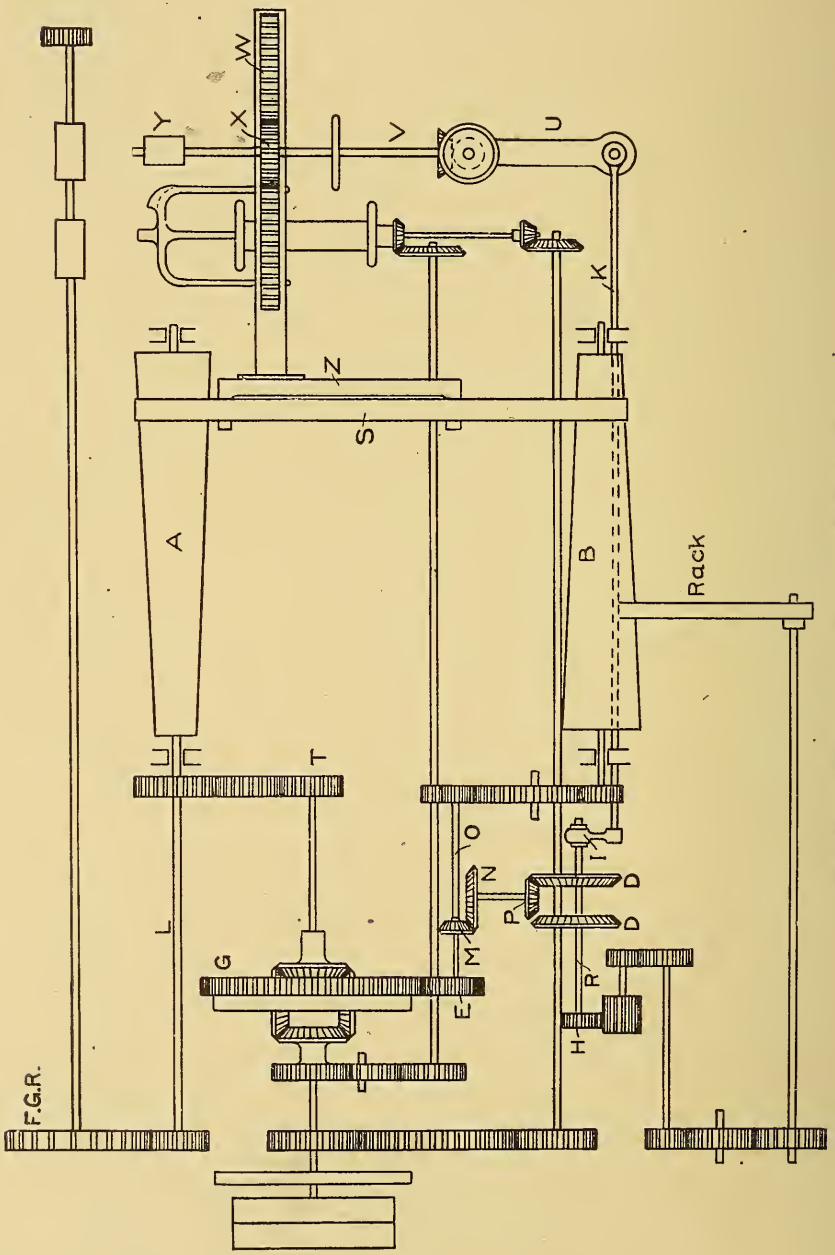


Fig. 126. Diagrammatic View of Cone Drawing Frame.

there are then 310 revolutions or a reduction of thirty caused by the action of the cones.

In Fig. 126, on the shaft O, there is a small bevel pinion M which gears into N which is fixed on the top of a vertical shaft, at the opposite end of which is another pinion P which can engage either of the two bevels D, D^1, when they are pushed into gear. The bevels D and D^1 are held firm by keys to the shaft R, which has the lifter change wheel H on one end. At the other end is a claw I for the purpose of sliding the shaft R so as to engage D and D^1 alternately with P, at the change of the traverse, thereby changing the direction of H, which is connected with the lifter by means of a train of gears. The shaft R is connected with the building motion or lifter by a rod K attached to a lever U. The vertical shaft V works in conjunction with the lifter, and actuates the rack W and belt fork Z through the gear X.

A bevel gear is attached to the base of the shaft V, which gears with another on the horizontal shaft of the lifter motion, which also has a ratchet change gear controlled by two pawls. At the top of this shaft V is placed a barrel which carries a weight. The weight assists the belt in traversing the cone and makes its motion uniform.

Unlike the heavy drawing frames the smaller frames have two rows of spindles; one set behind and alternating with the other, allowing the greatest number of spindles to be placed in a given space. Each spindle is driven by a pair of skew bevel gears. The smaller is fixed near the bottom of the spindle for driving and to allow for the traverse of the bobbin. It is fastened by a set screw which makes it easy to adjust, and meshes with a larger gear on the driving shaft. As each row of spindles is driven by a long shaft and these shafts are geared so as to be of the same speed as each other, it gives a very uniform tension to all the ends.

Since the cones regulate the speed it will be well to see how the speed is conveyed from the socket gear to the differential motion. As the bobbin is being filled the bevel is always changing, owing to the influence of the lifter, thus making it necessary to mount the connecting gears between the socket gear and bobbin shaft gear in such a manner that the continuity of motion shall be maintained regardless of the movement of the bobbin rail. Different methods are used by different manufacturers.

In Fig. 127, an arrangement is shown where an intermediate

gear is mounted in a swing. S is the driving gear, J the intermediate, and B the bobbin shaft gear. The stud upon which J works is supported in a curved bracket with a slot to allow for the movement caused by the lifter. This method is objectionable because the speed increases as the lifter descends, caused by J being partially carried around S during the traverse of the lifter, the amount being governed by the length of the traverse.

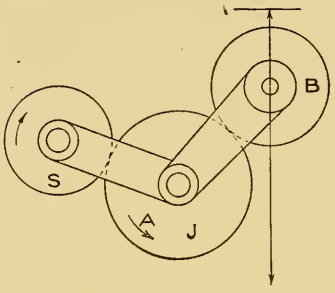


Fig. 127.

We will assume that J is rotating, as shown by the arrow A, but its rolling contact with S also gives it speed, and if both wheels are the same size, during the traverse J has to be carried one-fourth around S, therefore, it gains half a revolution in excess of its normal speed. S and J drive B and so influence it in a similar manner.

A second manner is shown in Fig. 128, the socket wheel being a bevel. A gears into a second gear B fixed upon a swing shaft C; at the other end of the shaft is a third bevel gear D gearing with another F, attached to the driving bobbin E. The wheel D has a sunk key in the shaft to allow it to adapt itself to the decrease and increase of distance required during the lift. The gears are kept in position by collars, while the box G and the swing bearing H enable the angle of the bearing to change. This arrangement also is somewhat affected by the rolling motion.

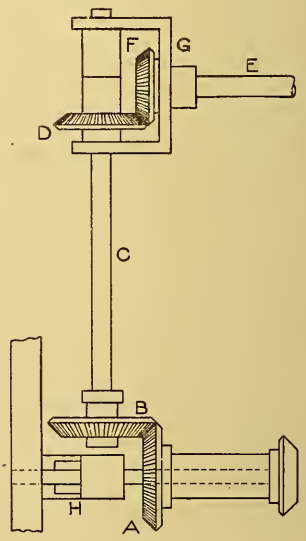


Fig. 128.

Bobbin Lead and Flyer Lead. The relative merits of the two methods of winding should be considered. The bobbin lead is generally used as it gives the most satisfactory results. This is due to the fact that in the driving of the spindles and bobbins two distinct trains of gears

are employed. The train which drives the spindles is directly connected with the main shaft and consists of only three or four gears, so that when the machine is started little or no delay occurs.

The train of gears which drives the bobbin is much more complex. In the first instance there is the friction drive of the cones which is liable to a certain amount of slippage, particularly if the cone belt is not adjusted properly. In this connection it should be said that the cone belt should be made endless and have pressed lap joints, both sewn and cemented, so as to secure a regular surface and to prevent, as much as possible, the accumulation of grease. From the bottom cone there are gears driving the differential motion and then the bobbins, so there is much more opportunity for delay in the commencement of the bobbins.

When the winding is done by the spindles or what is termed the *flyer lead*, this difference in starting is serious, especially in the case of small slivers, due to the strain placed on the sliver caused by the pull of the spindles before the bobbins begin to move. Another objection to this method of winding is that when an end breaks down, the bobbin, continuing to revolve behind the flyer, has a tendency to unwind the material, which often becomes entangled with the other slivers or catches in the bevel gears, thus causing a large amount of waste and in some cases breakage of gears.

FRENCH DRAWING

The French system is especially adapted for short fine wools whose staples range from $2\frac{1}{2}$ to 6 or 7 inches, though wool which measures as high as 10 inches is sometimes drawn. However, fine wools with staples varying from $3\frac{1}{2}$ to $4\frac{1}{2}$ inches may be taken as a good average length for ordinary French drawing.

The principle of the English systems of drawing is to draw the slivers by means of revolving rolls and then twist them into a rope-like form and wind on bobbins by means of flyers. In the French system the principle of drawing by means of rolls is used, but in other respects it is widely different. No twist is given the slivers, the fibers being kept as straight and parallel as possible until the spinning operation is reached.

Principle. Throughout the whole process of French drawing the slivers are drafted between three pairs of top and bottom rolls;

termed the *back, middle,* and *front rolls.* Between the middle and front rolls what is termed a *porcupine roll* is placed. There are a number of brass rings, through which steel pins are inserted, fixed on the porcupine roll, hence its name. The sliver passing from the back and middle rolls to the front roll passes between these pins, which serve the same purpose as the fallers in a gill box.

The porcupine roll revolves slightly faster than the back rolls, but slower than the front rolls, and is fitted in a position a little higher

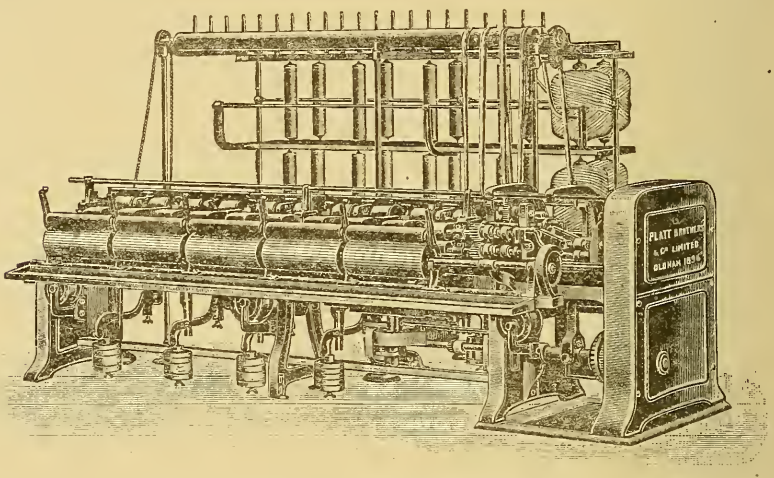


Fig. 129. First and Second French Drawing Frames.

than the nip of the rolls. The reason for this is to support the slivers and to ensure a thorough combing.

The greatest care is needed in setting these machines, to be sure that the porcupine rollers are placed in their correct position or elevation, as regards the *nip* of the back, middle and front rollers, for it is absolutely necessary that the pins pass through the full thickness and along the whole width of the slivers. The surface of the porcupine roll varies from $\frac{1}{8}$ to $\frac{7}{16}$ of an inch above the level of the nips of the front, middle and back rolls. The slivers should rest on the surface of the brass rollers at the bottom of the pins.

Rubbing Motion. The wool, after it has been drawn through the porcupine by the front rollers, passes through a pair of rubbing leathers or aprons, which have not only a rubbing motion to rub the slivers into round condensed threads, but also have a revolving motion to wind them on bobbins. These bobbins are placed horizontally

on two fluted revolving rolls fixed to a traversing rail which, moving rapidly from end to end of the bobbins, causes the slivers to cross and re-cross each other as they are being wound on the bobbins.

Single Meche and Double Meche. Two ends are generally wound on each bobbin throughout the whole system of French drawing, commencing with the first drawing frame, though some firms believe in having only one end per bobbin for the first drawing frame. Bobbins with one end or sliver are called *single meche*, and those with two ends are called *double meche*. The terms single and double meche may cause some confusion.

Single meche or single end bobbins are put into the creel and come out double meche bobbins in the front; that is, with two ends on a bobbin. In the other instance, double meche bobbins are put into the creel of the next frame and come off on double meche bobbins in the front; that is, the bobbins have two threads at both the feed and delivery.

We will deal with the first drawing frame, a type of which is shown in Fig. 129. Assume that it has 8 bobbins at the front or delivery side, and that there are 32 bobbins or balls from the gill balling machine in the creel, each being composed of one thread, and each bobbin on the delivery side having two ends. In this way, it will be seen that there are 32 ends in the creel to be drawn into 16 ends, or two ends on each of the eight bobbins delivered, thus giving a doubling of two into one. Now in the second drawing frame, which we will say has 8 bobbins in front and 32 bobbins in the creel, we get a doubling of four into one, for the reason that in this case each bobbin, both in the creel and delivery, has two ends.

In France it is customary to adopt single meche for the first and second drawing frames, and to commence double meche with the bobbins which are made on the third drawing frame.

Operation. On an ordinary set of French drawing for producing a five dram roving, at the finishing roving frame, nine operations are generally sufficient, but the number of operations or frames varies according to the number of doublings required, the dram roving wanted at the finishing roving frame, and the quality of wool being dealt with. In some cases only seven or eight passages are necessary when dealing with coarse counts, while for very fine counts, twelve or even thirteen passages are essential.

The above explains the principles of French drawing. Two, three, or four ends are always doubled into one, drawn through porcupines, rubbed and wound on horizontal bobbins, with two ends per bobbin, without twist being put into the slivers. This process must impress one as being superior for soft bulky yarns to the English system, where at every operation twist is put into the sliver, making it into a sort of hard rope-like end which is drawn and redrawn, and twisted and retwisted at every succeeding operation.

The most important part of every French drawing frame is the porcupine roller, in the construction of which, so far as the pinning is concerned, lies what one may say is the secret of good drawing and spinning. The most suitable number of rows of pins, the pitch, thickness, and shape for the various kinds of wools used have only been arrived at by long experience and very careful attention and study. A book could be written on the porcupine regarding its height or level in relation to the other rollers, its diameter, the shape of its pins, and their size, as regards length and thickness, at each operation.

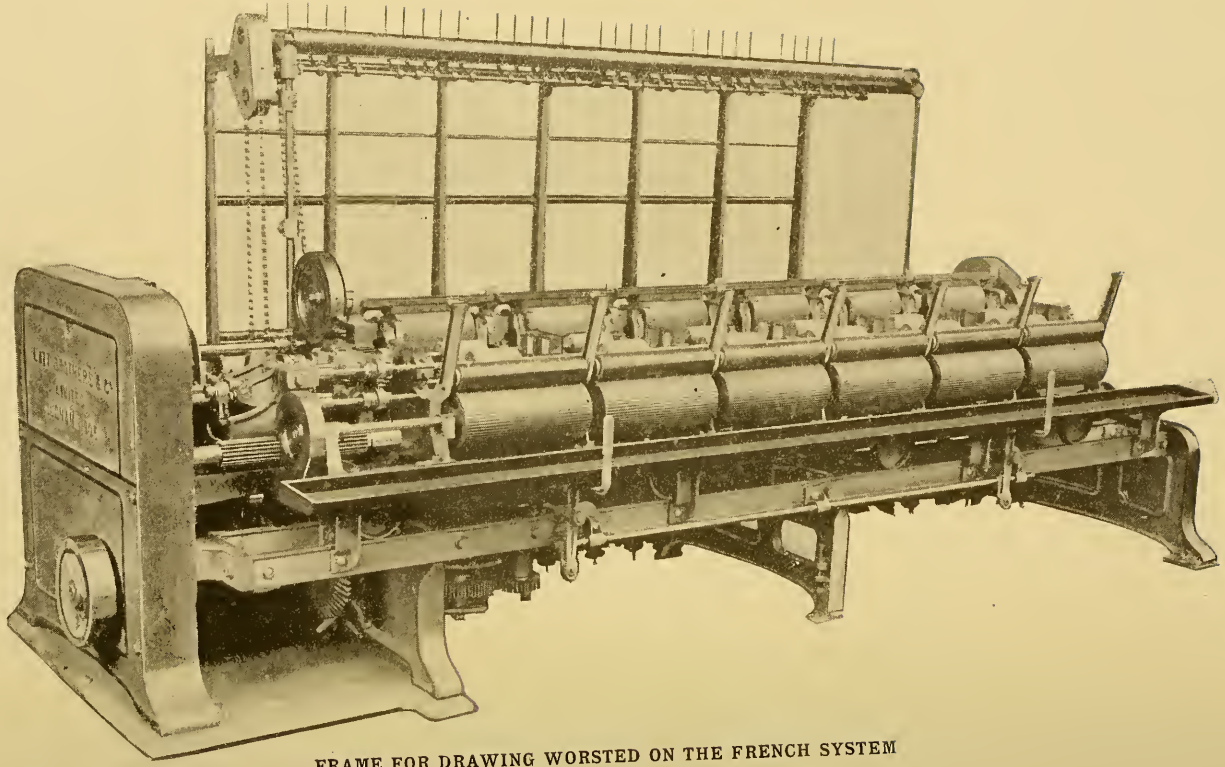
In place of rubbing aprons, finely fluted iron plates are being introduced. The slivers are rubbed between these plates, and it is claimed that they give the wool a more even rub and a better luster.

The pins in the porcupines or combs, as they are sometimes called, should be somewhat inclined, and point away from the front roller, so as to hold the wool more firmly during the process of combing. This causes them to get filled with dust and dirt and they should be cleaned from time to time.

To prepare 5400 pounds of roving of which 40 yards weigh 5 drams, or in other words 3.5 hank roving (which means that $3\frac{1}{2}$ hanks, each containing 560 yards, weigh one pound), in a week of 50 working hours, the following drafts and doublings are necessary. The process comprises nine operations the first consisting of two six-spindle gill boxes.

At each of these gill boxes four ends are doubled into one so there are twenty-four tops at the back. The draft at this box is 6.6, the diameter of the front roll is 2 inches, and it runs at a speed of 60 revolutions per minute. The tops weigh 256 drams for 40 yards, or are .0714 hank sliver, which with a draft of 6.6 gives a 155 dram or .1178 hank sliver on the bobbins.

The weight produced per bobbin on these boxes is 475 pounds,



FRAME FOR DRAWING WORSTED ON THE FRENCH SYSTEM

Platt Bros. & Co.

or 2850 pounds per box, which gives a total for the two boxes of 5700 pounds per week. Each bobbin will contain 10 pounds of sliver.

Thirty-two of these bobbins are taken to what is really the first operation in the French drawing, namely, the first drawing frame, and placed in the creel. This frame has eight bobbins in front, so four bobbins are doubled into one; but as the bobbins in front have two ends on each, only two ends and not four ends are doubled into one. It may be well to state here that all the operations in this process are double meche. The draft here is four; the diameter of the front roller, $1\frac{3}{4}$ inches; and the speed of the front roller 120. The bobbins in this frame are $15\frac{3}{5}$ inches long, and hold about $8\frac{3}{4}$ pounds of sliver.

The dram sliver is 77.67 and the hank sliver .2356. The hanks per sliver (not per bobbin, as there are two ends on a bobbin) are about 100 per week.

Thirty-two of the bobbins from the first drawing frame are then placed in the creel of the second drawing frame, which is a similar machine to the first.

As the bobbins in the creel of this frame are double meche, and not like those in the creel of the first drawing frame, there will be different doublings as regards the number of ends, though there are still four bobbins at the back, doubled into one bobbin at the front. Yet as each of the bobbins in the creel has two ends, like those in front, there are really eight ends on each bobbin in front, but only four ends doubled into one. With a draft of 4.5 a dram sliver of 69, or a hank sliver of .2650 is produced. The diameter of the front roll is $1\frac{3}{4}$ inches and the speed 120, the same as on the first drawing frame. The bobbins are $15\frac{3}{4}$ inches long and each one holds about $7\frac{3}{4}$ pounds of sliver.

Twenty-four of these bobbins are placed in the creel of the third drawing frame which has twelve bobbins in front; giving a doubling of two ends into one, with a draft of 3.4. The dram sliver is 40.62 and the hank sliver .4504. The diameter of the front roller is $1\frac{3}{8}$ inches and the speed is 164. The bobbins are $15\frac{3}{4}$ inches long and each one contains about 7 pounds of sliver.

Forty-eight of these bobbins are placed in the creel of the next frame, which is the reducer or reducing frame, with twenty-four bobbins in front, giving a doubling of two ends into one, with a draft of 3.9. The dram sliver from this frame is 21.06 and the hank sliver

.8784. The front roller is $1\frac{3}{8}$ inches in diameter and its speed is 169. The bobbins are $9\frac{3}{4}$ inches long and each one holds 5 pounds of sliver.

Ninety-six bobbins from here are placed in the creel of the next machine, which is the slubbing frame. This also has twenty-four bobbins in front but four ends are doubled into one, with a draft of 4.1. The dram sliver is 20.32, and the hank sliver .9003. The diameter of front roll is $1\frac{1}{8}$, and the speed is 197. The bobbins are $9\frac{3}{4}$ inches long and hold about 3 pounds of sliver.

Ninety-six of these bobbins are placed in the creel of the next machine, which is the first intermediate frame. There are twenty-four bobbins in front. Four ends are doubled into one, with a draft

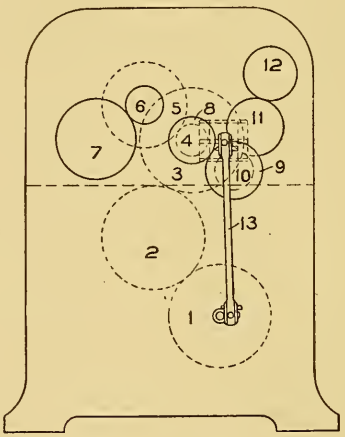


Fig. 130. Driving Head.

of 4.4, which gives a dram sliver of 18.48, or a hank roving of .9903. The front roll is $1\frac{1}{8}$ inches in diameter and runs at 227 revolutions per minute. The bobbins from this box are 8 inches long and hold about $2\frac{1}{2}$ pounds of sliver.

Ninety-six bobbins from here are placed in the creel of the next operation, which is the second intermediate frame. This also has twenty-four bobbins in front, four ends being doubled into one, with a draft of 4, so that the sliver will be the same as in the previous operation. The front roll is one inch in diameter, and has a speed of 220. The bobbins from this frame also are 8 inches long and hold about $2\frac{1}{2}$ pounds of sliver.

Ninety-six bobbins from here are placed in the creel of the next

machine, which is the roving frame. This has forty-eight bobbins in front so only two ends are doubled into one, with a draft of 3.7. The dram roving is 10, or the hank roving 1.832. The front roller is 1 inch in diameter and runs at 220 revolutions per minute. The bobbins are 8 inches long and hold about $2\frac{1}{2}$ pounds of sliver.

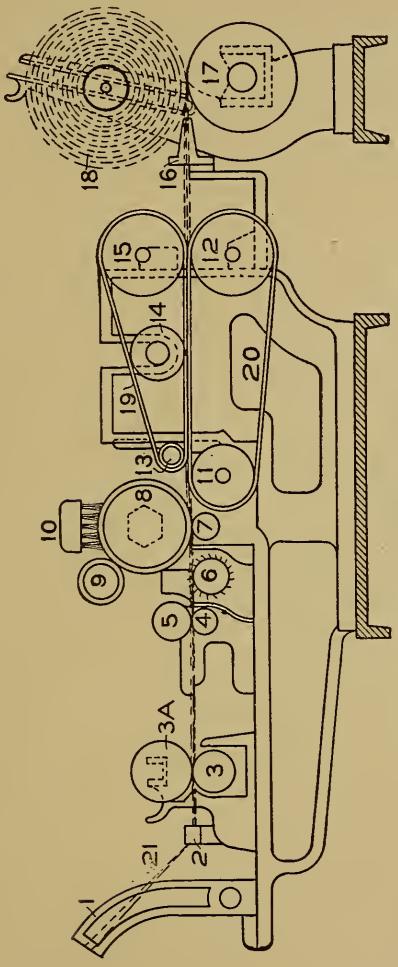


Fig. 131. Sectional Side View of French Drawing Frame.

From here the bobbins are taken to two finishing roving frames, each frame containing forty-eight bobbins in front. Ninety-six bobbins from the last roving frame are placed in the creel of each of these two finishing roving frames, two ends being doubled into one,

with a draft of 3.91. The resulting sliver or roving weighs 5.11 drams, or is 3.58 hank, the required size approximately. The diameter of the front rolls on these machines is one inch and the speed is 220 revolutions per minute. The bobbins are 8 inches long and hold about $2\frac{1}{2}$ pounds of roving.

Construction. The illustration shown in Fig. 130 shows the driving head. The larger gear 1 is on the driving shaft, and carries the crank arm 13, which actuates the traverse motion of the aprons (19 and 20 in Fig. 131). The motion of the aprons is the same as the apron condenser on the finisher card of a woolen set; *i. e.*, a side-

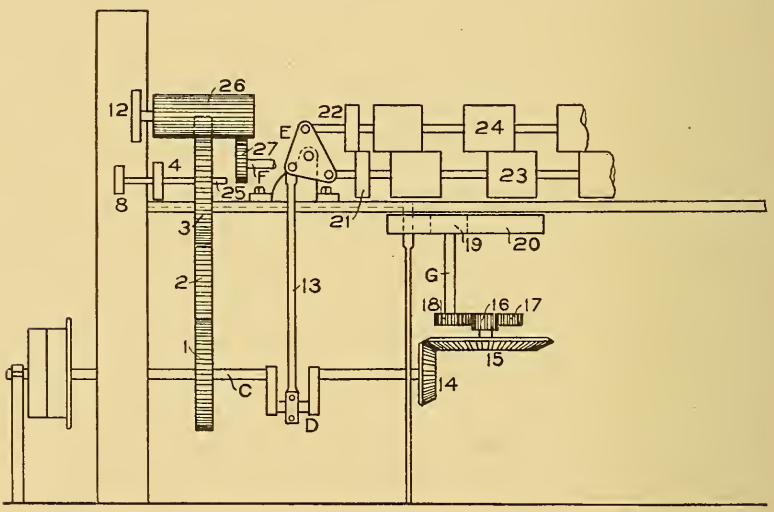


Fig. 132. Showing Mechanism for Driving Rub Aprons.

wise motion to rub or condense the roving. They also have a revolving motion to carry the roving forward to the calender roll 17 (Fig. 131).

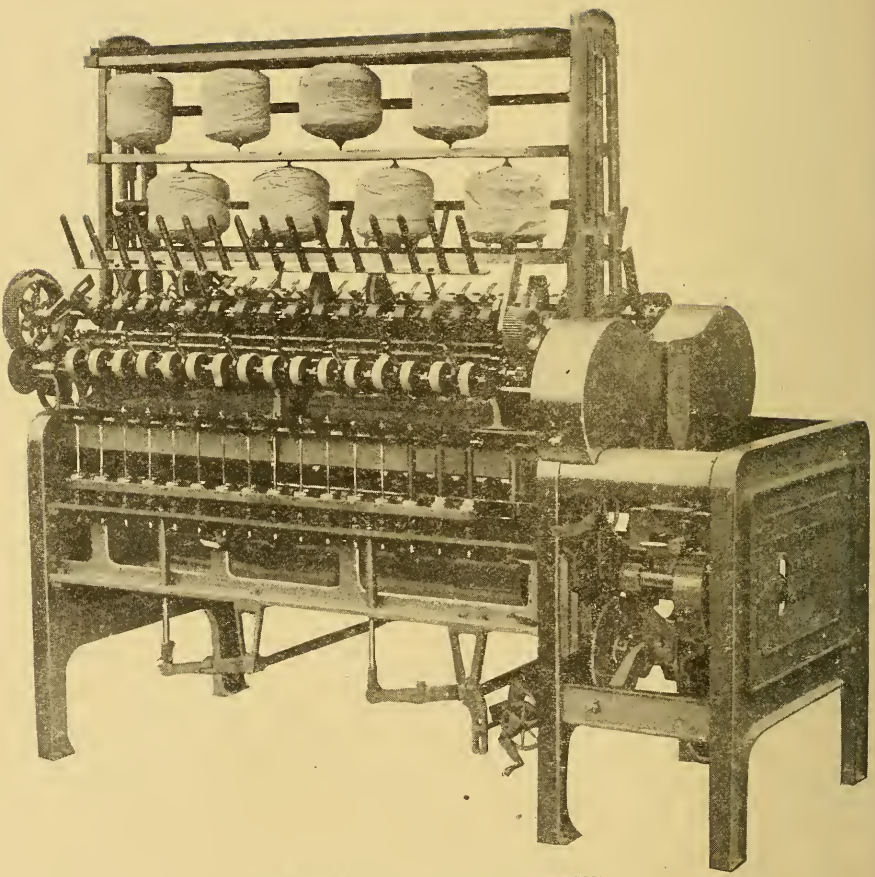
The gear 1 (Fig. 130) also drives the intermediate gear 2 which in turn drives the gear 3 on the front roll shaft. The gear 4 also is on the front roll shaft, inside of 3, and drives the inside stud gear 5. The gear 6 is on the same stud as 5 and drives the gear 7 which is on the back roll shaft, and through which the back roll receives its motion. The gear 12 is on the calender roll shaft and receives motion from the front roll shaft through the gears 8, 9, 10 and 11.

A sectional view is shown in Fig. 131. 1 is a guide to guide the

slivers to the small trumpet guide 2, which sets on a traverse rail and causes the roving to traverse across the surface of the back rolls 3 and 3A. 4 and 5 are carrier rolls, 6 is the porcupine, and 7 and 8 are the front rolls. The roll 9 and the brush 10 are to remove the dirt which would otherwise accumulate on the roll 8. 11 and 12 are rolls which carry the bottom apron 20, and 13, 14, and 15 answer the same purpose for the top apron 19. 16 is a trumpet guide, 17 is the calender or winding roll, and 18 is the ball of sliver ready for the next operation.

The illustration, Fig. 132, shows the method of driving the upper and lower rub or condensing aprons. B is the driving pulley; C is the main driving shaft; D is the crank, which, through the crank arm 13 actuates the oscillating motion of the rub aprons; E is the eccentric attached to the crank arm 13, and to the rub apron shafts. It will be seen that when the crank shaft is in motion through the eccentric, the top rub apron 24 will move in one direction while the bottom rub apron 23 moves in the opposite direction. The surfaces of the aprons are thus rubbing against each other. The roving runs between them and is rubbed into a round thread of roving. 1 is the large gear on the main shaft, which, through the intermediate gear 2, drives the front roll gear 3.

On the shaft with 12 is the long gear which allows the gear 27 to traverse the full width of the ball of roving. F is the shaft on which the winding or calender rolls are placed and on which the gear 27 is placed. It receives its traverse motion from the mangle wheel 20. The mangle wheel is driven by the gear 19, which is fastened on the upright shaft G at the other end of which the gear 18 is fixed, and receives motion from the gear 17, which in turn is driven by the gear 16. 16 is on the same stud with the bevel gear 15, which is driven from the bevel gear 14 on the main shaft.



WORSTED RING SPINNING FRAME
Platt Bros. & Co.

WOOLEN AND WORSTED SPINNING

PART IV

SPINNING

The rovings from the last frame of a set of drawing, and from the condenser of a finisher card are carried to the spinning room for the final operation in yarn manufacturing.

As in the preparatory operations, the methods used on worsteds differ from those employed on wool, the object of the latter being to produce a soft thread in which the ends of the fibers protrude from the core, while the object of the former is to produce a yarn in which the fibers lie parallel to each other and lengthwise of the thread.

WORSTED SPINNING

There are four distinct methods of spinning worsted yarns: the *flyer frame, cap frame, ring frame,* and the *worsted mule* used for spinning roving made on the French system of drawing. The flyer frame was the first to come into use; the cap frame came next; and was followed by the ring frame. The mule of the French system is distinctly different from the others and must be considered quite apart from them.

The spinning process may be divided into three operations as follows: *first,* drawing out or drafting; *second,* twisting the drawn out fibers; and *third,* winding the fibers (which are now yarn) on the bobbin. The third operation, though necessary in any practical system of spinning, is not actually a part of the spinning operation for the yarn is spun before it is wound on the bobbin as may be seen in the case of the mule, which is an intermittent motion. However, the winding operation is performed on the spinning frame and is of great importance, so it will be considered a part of the spinning process.

The flyer, cap, and ring frames differ only in the construction of their spindles, methods of imparting twist, and winding the yarn on bobbins.

Flyer Spinning Frame. The flyer frame is built on the same principle as the open drawing machines. It has back, front, and carrier rolls to draw out the roving, and spindles, with flyers screwed to the top, to impart twist and wind the yarn on the bobbins.

The illustration shown in Fig. 133 represents a flyer spinning frame and shows very clearly the principles on which it works. The bobbins of roving doffed from the roving frame of the drawing set are placed on the pegs at the top of the frame. The ends are then passed between the back rolls which slowly draw the rovings from the bobbins and pass them to three sets of carrier rolls, which in turn pass them to the front rolls. The front rolls draw out the roving as much as required and pass the attenuated end to the flyer, around one wing of which it is wound once or twice and then passed to the bobbin.

The diagram, Fig. 134, shows how the above operations take place. 1 is a bobbin of roving which is supposed to be set in the creel provided for that purpose. The end of roving is drawn from the bobbin and passed through the roving guide 2 to the back rolls 3 and 3A. From the back rolls the roving is carried by the rolls 4 to the front rolls 5 and 5A, which, like the front rolls on a drawing frame, revolve faster than the back rolls and give the draft. The difference between the surface speed of the front and back rolls is the *draft*, or represents the number of inches of yarn drawn out of one inch of roving.

The standard diameter of the bottom back roll 3A is one and one-quarter inches, while the bottom front roll 5A is made in $2\frac{1}{2}$, 3, 4, and 5-inch sizes for different kinds of stock. The four-inch roll is commonly used and will be taken as the standard. The reason for giving the sizes of the bottom rolls instead of the sizes of the top rolls is because the latter are driven from the former and therefore must have the same surface speed regardless of their size.

By again referring to Fig. 134, it will be noticed that the yarn passes from the front rolls through an eye board to the flyer and is wound on the bobbin B. The bobbin is carried up and down on the spindle by the lifter plate which moves up and down the spin-

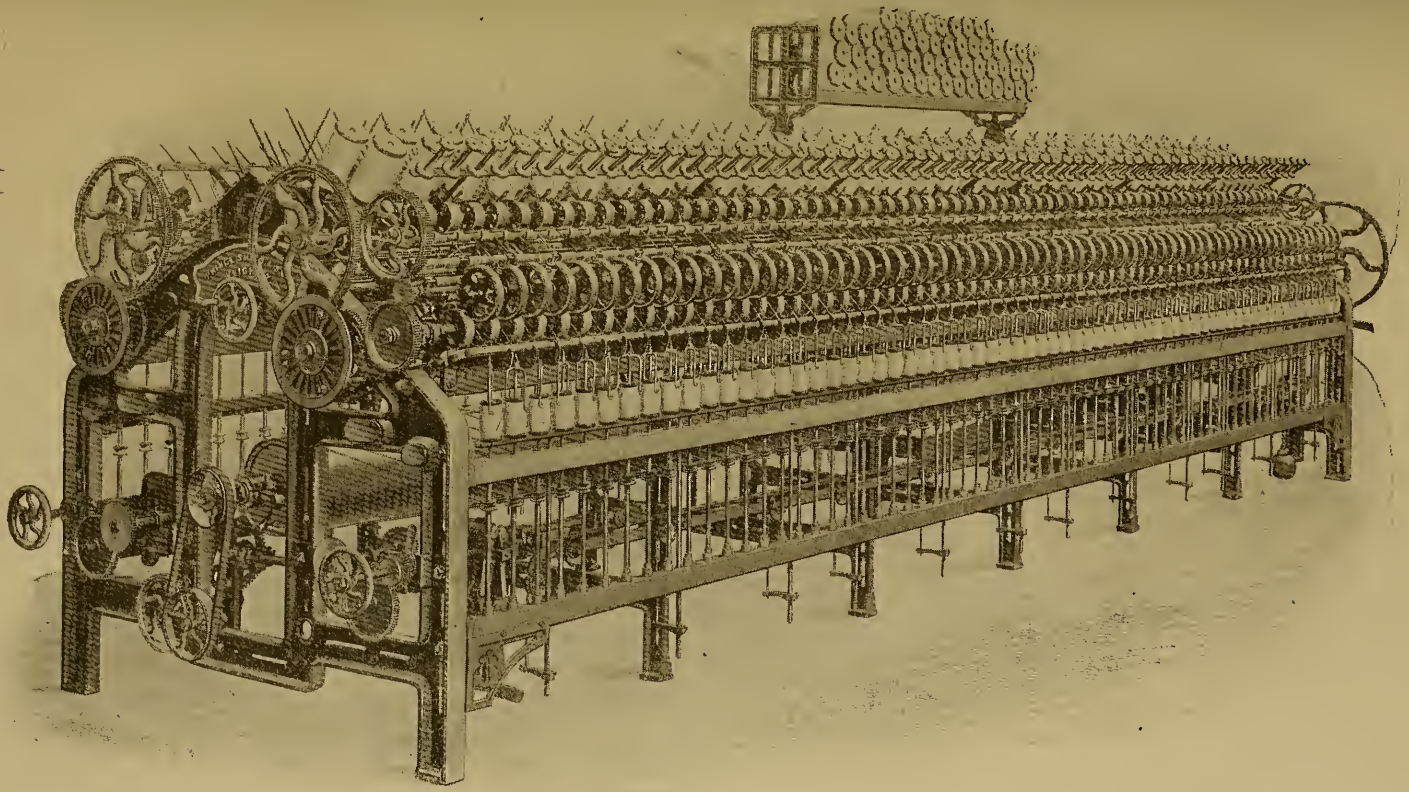


Fig. 133. Flyer Spinning Frame.

dle. Three kinds of bobbins are used: *a*, the ordinary bobbin with a head at each end and which fills evenly from one end to the other; *b*, the tube which requires a double motion to fill it, namely, the ordinary up and down motion traversing about one and one-half inches, and a constantly lowering motion, which ultimately causes the tube to be filled over its entire length but to be much larger in

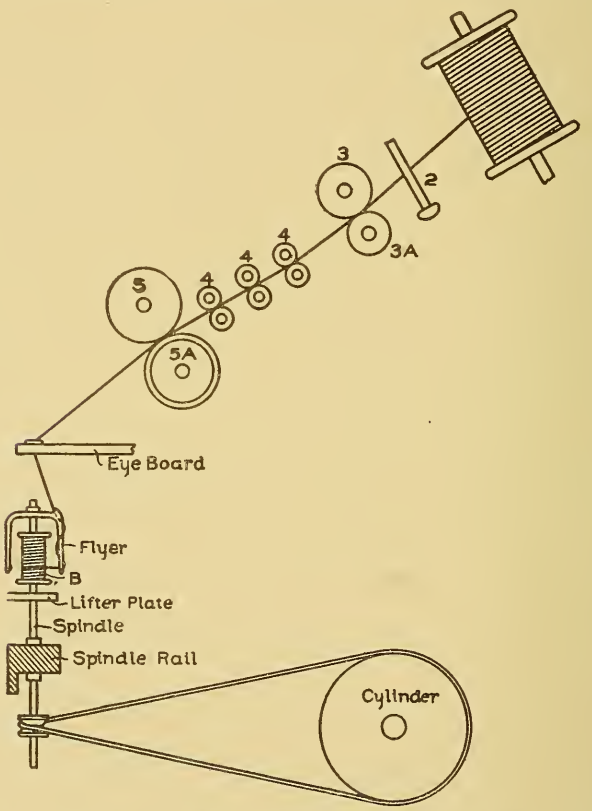


Fig. 134. Drawing Showing Method of Drafting, Twisting and Winding.

diameter at the middle than at the ends; and *c*, the bobbin which has a flange at the lower end, and which requires three motions to fill it, *i. e.*, a very short one at first which fills the lower end and during which the lifter plate traverses very little, and a longer traverse with a constantly lowering motion the same as for a tube, so that the full bobbin gradually tapers from the bottom toward the top.

The spindles are driven by bands which pass around a whirl on the spindle and a cylinder which is on the main shaft of the spinning frame.

Calculations. The illustration, Fig. 135, is a plan of the rolls and the gearing that drives them. A is the back roll, B is the front roll, C the draft change gear, D the inside gear of the double stud, E the outside gear of the double stud, and F is the back roll gear. X, Y and Z are the small carrier rolls. This illustration is to show the method of figuring the draft of the frame.

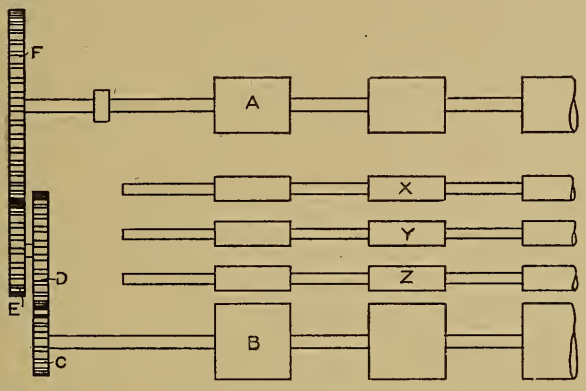


Fig. 135. Plan of Draft Rolls and Gearing.

To find the draft of a spinning frame: Multiply the diameter of the bottom front roll by the number of teeth in the driving gears and divide the product by the product of the diameter of the back roll multiplied by the number of teeth in the driven gears. To prevent confusion in determining which are the driven and which are the driving gears the following statement should be memorized: All gears which if increased in number of teeth would increase the draft are drivers, and all gears which if increased in number of teeth would give less draft are driven gears.

Explanation. As the back roll A delivers the roving to the front roll B it is evident that if it were increased in size it would deliver more roving to the front roll, therefore the draft would be reduced. On the other hand, if the size of the front roll B were increased it would draw out the roving more, consequently the draft would be increased.

If the draft change gear C, which is on the front roll shaft, were increased in size it would drive the back roll faster in proportion to the front roll and therefore deliver more roving to the front roll, consequently making the draft smaller. If the inside stud gear D were increased in size it would have the opposite effect, increasing the draft. If the outside stud gear E were increased in size it would have the same effect as increasing the size of C. If the back roll gear F were increased in size it would have the same effect as increasing the size of D.

As the diameter of the front roll is 4 inches and gears D and F each have 100 teeth, and as the diameter of the back roll is $1\frac{1}{4}$ inches and gears C and E have 64 and 84 teeth respectively, the calculation would be as follows:

$$\frac{4 \times 100 \times 100}{1\frac{1}{4} \times 64 \times 84} = 5.95 \text{ Draft}$$

To facilitate the work of calculating the draft with different change gears the constant is found by leaving the number of teeth in the change gear out of the calculation.

$$\frac{4 \times 100 \times 100}{1\frac{1}{4} \times 84} = 380.95 \text{ Constant}$$

To find the change gear required to give a certain draft: Divide the constant by the draft.

For example, if the draft given above were required the calculation would be as follows:

$$\frac{380.95}{5.95} = 64 \text{ Change gear}$$

To find the draft with any size change gear: Divide the constant by the number of teeth in the change gear.

For example, if a change gear of 47 teeth were used the draft would be as follows:

$$\frac{380.95}{47} = 8.1 \text{ Draft}$$

Carrier Rolls. In Fig. 135 there are three rolls marked X, Y, and Z, between the front and back rolls. These rolls do not affect the draft, their purpose being to support the roving in its passage from the back to the front roll. There is, however, a small

draft between the back roll and the back carriers and also between each of the pairs of carrier rolls. This, however, does not affect the draft of the frame and is merely to keep the roving straight.

As previously explained in connection with Fig. 133, the thread of yarn drawn out from the roving is wound around one leg or wing of the flyer, then passed through the eye at the bottom and wound upon the bobbin. As the spindle revolves the bottom travels up and down on the traverse rail, which allows the flyers to guide the yarn as required to build a good bobbin of yarn.

Twisting and Winding. In twisting and winding the yarn, the flyer operates on the same principle as in open drawing. The spindle or rather the flyer puts twist into the yarn in the following manner: The yarn is passed through the eye of the flyer and as the flyer revolves it carries the yarn around with it, giving one turn of twist for each revolution.

The yarn is delivered by the front rolls at a constant speed and must be wound on the bobbin at the same speed. If the bobbin and flyer traveled at the same speed there would be only twisting, no yarn being wound on the bobbin, but as the bobbin is loose on the spindle its tendency is to remain stationary, and it is dragged around by the yarn. Thus the amount of yarn wound on the bobbin represents the difference in the speeds of the bobbin and flyer.

As the diameter of the bobbin increases it is dragged around faster. This statement may seem puzzling at first and will bear further explanation.

We will call the speed of the flyer 3000 R. P. M., and the speed of the empty bobbin, which we will call one inch in diameter, 1500 R. P. M. As the circumference of a one inch bobbin is 3.14+ inches, each revolution that the flyer makes more than the bobbin will wind 3.14+ inches of yarn on the bobbin, and while the flyer is making two hundred revolutions it will wind $100 \times 3.14+$ inches or 314+ inches of yarn on the bobbin.

When the bobbin is two inches in diameter, its circumference is 6.28+ inches and if the flyer and bobbin continue to run at the same relative speed, two hundred revolutions of the flyer will cause 628+ inches of yarn to be wound on the bobbin. As the speed of the flyers and the delivery of the front rolls are constant this could not be done.

The diagrams shown in Fig. 136 will help to make this plain. Number 1 shows the flyer as having made one-half of a revolution from A to B, and the empty bobbin, which we will call one inch in diameter, one-quarter of a revolution, from C to D. The length of the yarn wound will be equal to the distance around the barrel

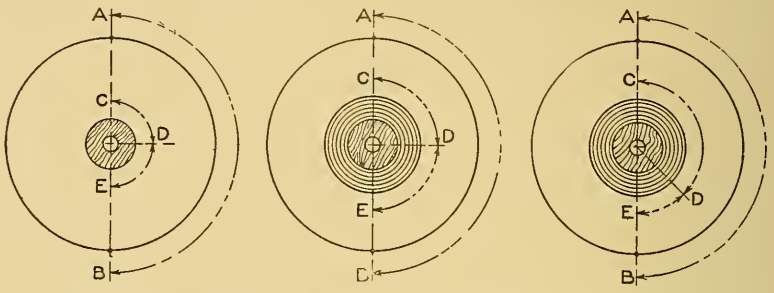


Fig. 136. Diagram Showing Difference in Speeds of Flyer and Bobbin.

of the bobbin from D to E which is one-quarter of its circumference or about .78 of an inch.

Diagram number 2 shows the bobbin as two inches in diameter. The flyer has made one-half of a revolution from A to B, the same as in Diagram 1, and the bobbin has made one-quarter of a revolution, from C to D. The length wound is indicated by the distance around the bobbin from D to E, which is 1.57 inches, twice as much as in Diagram 1 where the bobbin is empty.

Now as the speed of the flyer is constant and the length of yarn delivered by the front rolls is always the same, it is evident that the amount wound upon the bobbin can be only what is delivered by the front rolls, and as the larger the bobbin grows the greater is its circumference, the only way that the same length of yarn can be wound is by increasing the speed of the bobbin so that the same ratio in its circumferential velocity shall be maintained at all times between it and the flyer.

Diagram number 3 shows the bobbin two inches in diameter. In order to wind the proper length of roving the bobbin makes about three-eighths of a revolution or from C to D while the flyer travels from A to B. The length of yarn wound on the bobbin is represented by the distance D–E, which, measured on the circumference of the bobbin, will be found to be the same as the distance D–E in the first diagram.

As the bobbin increases in size it becomes heavier and, as shown in Fig. 136, travels faster. This increased weight increases the friction and in order to regulate the drag, washers of cloth or leather are placed on the spindle between the bobbin and the lifter plate.

Cloth washers drag very much lighter than leather washers and are generally used for the lighter counts of yarn. When cloth washers do not drag sufficiently hard a leather washer is placed on top of the cloth washer. This method of regulating the drag is one of the difficult points in flyer spinning and requires good judgment.

The drag of the yarn can also be regulated by winding the thread around the wing of the flyer. For instance, if it is wound three times around the wing, the drag is less than if it were wound around once, or not at all. The reason for this is that when the yarn is not wound around the wing but merely hooked in the eye at the end of the wing, the bobbin drags the yarn all the way from the nip of the front rolls, but when the yarn is wound two or three times around the wing the drag of the bobbin is almost wholly confined to the comparatively short distance between the eye of the flyer and the surface of the bobbin. Wrapping the yarn around the flyer wing therefore has the effect of preventing the tension from getting above that point, which leaves the yarn between the top of the flyer with very little strain.

The twist is put into the yarn, as it leaves the front rolls, by the spindles and flyers, which have a speed of about 2800 revolutions per minute. The front rolls have a speed of about forty revolutions per minute and are usually four inches in diameter. Taking these as the actual figures for the purpose of calculation, the method of finding the twist would be as follows:

The diameter of the front roll being four inches the circumference would be twelve and one-half inches, approximately, and as it makes forty revolutions per minute the length of yarn delivered per minute would be five hundred inches. The spindle and flyer revolve twenty-eight hundred times while the bottom front roll is making forty revolutions.

Now it will be easily understood that if the yarn is held at the front rolls and the flyer is turned one revolution there will be one turn of twist in the yarn, so if the flyer is turned twenty-eight hundred

times while the front rolls deliver five hundred inches there will be twenty-eight hundred turns of twist in five hundred inches of yarn, or five and three-fifths turns of twist in every inch of yarn.

$$\frac{2800}{500} = 5\tfrac{3}{5} \text{ Twist}$$

The above may be termed the theoretical twist, as it makes no allowance for the loss caused by slipping of bands and consequent reduction in the speed of the spindle and flyer.

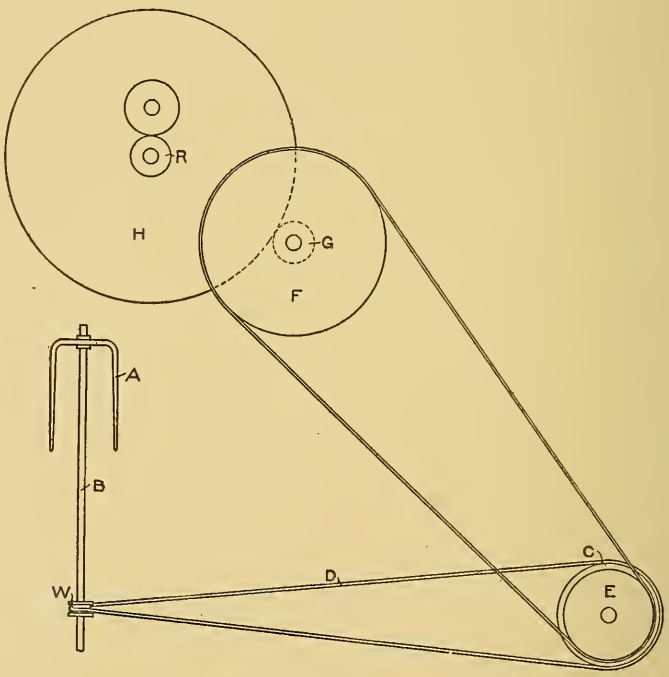


Fig. 137. Parts of Spinning Frame Affecting Twist.

The diameter of the bands also affects the twist. If the whirl of the spindle is V-shaped a small band will sink deeper into the groove than a large one, and therefore will have the effect of traveling around a smaller diameter than would be the case if a large band were used. It will be readily seen that the small band would drive the spindle faster and consequently put in more twist than a band of larger diameter.

Take-Up. The take-up due to twisting greatly affects the cal-

culations. For instance, if a yard of yarn is taken and twisted by hand it will be noticed that the yarn gradually grows shorter as twist is added. Taking this item into consideration with the other qualities which affect the twist it will be seen that the only way to find the actual twist is to test the finished yarn with a twist finder.

Calculations. The illustration in Fig. 137 is a diagram showing all the parts of the spinning frame which affect the twist in any way. A is the flyer; B the spindle; W the whirl; C the cylinder; D the band which drives the spindle; E the twist pulley which is on the cylinder shaft; F the twist pulley on the same stud as the change gear; G the change or twist gear; H the front roll gear; and R is the bottom front roll.

The dimensions of the parts which affect the twist are as follows: The whirl on the spindle is $1\frac{1}{4}$ inches in diameter; cylinder 10 inches diameter; twist pulley E, 9 inches in diameter; twist pulley F, 18 inches in diameter; change gear G, 34 teeth; front roll gear H, 268 teeth; and circumference of bottom front roll, $12\frac{1}{2}$ inches.

To find the twist: Multiply the diameter of the cylinder (10) by the diameter of the pulley F (18) and the number of teeth on the front roll gear H (268), and divide the product by the product of the diameter of the whirl ($1\frac{1}{4}$) diameter of twist pulley E (9), number of teeth in the change gear G (34), and circumference of the front roll $12\frac{1}{2}$.

$$\frac{10 \times 18 \times 268}{1\frac{1}{4} \times 9 \times 34 \times 12\frac{1}{2}} = 10 + \text{Twist}$$

By a careful reference to Fig. 137 and the above calculation it will be seen that all those factors which, if increased in size, would cause less twist to be put into the yarn are multiplied together, and all those factors which if increased would cause more twist to be put into yarn are multiplied together. The product of the latter is then divided by the product of the former and the quotient is the number of turns of twist per inch.

The twist constant may be found by omitting the change gear, and the turns of twist for a change gear of any number of teeth found by dividing the constant by the number of teeth on the change gear.

For example:

$$\frac{10 \times 18 \times 268}{1\frac{1}{4} \times 9 \times 12\frac{1}{2}} = 343.04 \text{ Constant}$$

To find the number of turns of twist with a change gear of 40 teeth divide the constant by 40.

$$\frac{343.04}{40} = 8.57 + \text{ Twist}$$

To find the change gear necessary to give 11.5 turns of twist divide the constant by 11.5.

$$\frac{343.04}{11.5} = 30 - \text{ Change gear}$$

The above calculations, however, give only the theoretical twist and if the yarn be tested it will be found that there is a loss of about 17 per cent, so that in place of 10 turns of twist, as calculated in conjunction with Fig. 137, there would be actually $8\frac{3}{10}$ turns per inch.

To find the *actual twist* the following method is often resorted to. A chalk mark is made on the top of the cylinder, as indicated by A in Fig. 138, and another mark made on the front of the spindle

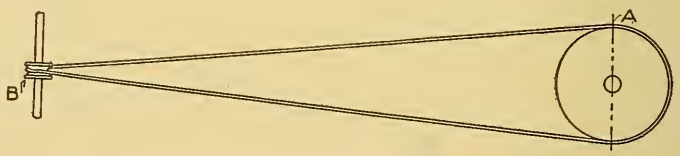


Fig. 138. Diagram Explaining Method of Finding Actual Twist.

whirl as indicated by B. The cylinder is then turned one complete revolution and the number of revolutions of the spindle counted very carefully.

With a 10-inch cylinder and a $1\frac{1}{4}$-inch whirl the spindle will make about seven revolutions to one revolution of the cylinder. Substituting these figures for the diameter of cylinder and whirl the calculation will give 8.83 turns of twist.

$$\frac{7 \times 18 \times 268}{1 \times 9 \times 34 \times 12\frac{1}{2}} = 8.83$$

Allowing five per cent for shrinkage or take-up on account of twist, the calculation would give very nearly the exact number of turns per inch in the yarn.

$$8.83 \times .95 = 8.39 \text{ Actual twist}$$

To find the constant omit the change gear:

$$\frac{7 \times 18 \times 268}{1 \times 9 \times 12\frac{1}{2}} = 300 \text{ Constant}$$

To find the change gear required for any number of turns of twist: Divide the constant by the number of turns of twist required as explained above.

To find the number of turns of twist when using any size change gear: Divide the constant by the number of teeth on the change gear, as explained above.

On cap spinning frames where the spindle whirls are smaller in diameter and are usually driven by tapes, the percentage of loss is even greater than on the flyer frames, and the above method of finding the actual twist will be found very useful.

Drafts. The methods of finding drafts and twists having been explained, the method of calculating the draft required to reduce a given weight of roving to the required number or counts of yarn will be taken up.

For example, if a 32s yarn is to be spun out of a 4 dram roving (which means that 40 yards of roving weigh 4 drams): Multiply the counts (32) by the dram roving (4) and divide the product by 18.3 which is the constant for 40 yards of roving.

$$\frac{32 \times 4}{18.3} = 7 \text{ Draft required}$$

If this draft is divided into the draft constant the quotient will be the change gear required to spin 32s yarn out of 4 dram roving.

The use of 18.3 as the constant for 40 yards of roving may cause some confusion. It is used to eliminate the necessity of including the number of yards in a hank of worsted and the number of drams in a pound, in the calculation.

The method of finding the constant of 40 yards of roving is as follows:

There are 560 yards in one hank of worsted (either yarn or roving) and as 40 yards is generally used in calculations the relation of 560 to 40 is found. As 560 divided by 40 equals 14 ($560 \div 40 = 14$), forty yards must be $\frac{1}{14}$ of a hank. There are 256 drams in a pound, so this is divided by 14 to give the weight of 40 yards of number one worsted yarn or roving.

$$256 \div 14 = 18.3 \text{ Constant}$$

The whole calculation may be summed up as follows: To find the constant for 40 yards of worsted, multiply the drams in one pound (256) by 40 yards and divide by the standard number of worsted (560).

$$\frac{256 \times 40}{560} = 18.3$$

If the roving is weighed in grains instead of in drams, as is sometimes the case, it is necessary to find a new constant as follows:

To find the constant for 40 yards of roving: Multiply the number of grains in one pound (7000) by 40 yards and divide the product by the standard number of worsted (560).

$$\frac{7000 \times 40}{560} = 500 \text{ Constant}$$

To find the draft required to spin a 32 yarn from 109.2 grain roving which is the same as a 4 dram roving: Multiply the counts (32) by the grain roving (109.2) and divide by the constant.

$$\frac{32 \times 109.2}{500} = 7 \text{ Draft}$$

Cap Spinning Frame. The only difference between the flyer spinning frames and cap spinning frames is in the construction of the spindle, with the consequent difference in the method of imparting twist to, and winding the yarn on bobbins. The arrangement of rolls for drafting is exactly the same.

The cap frame is especially adapted for fine counts of yarn, but coarse yarns also are spun on cap frames as the production is much greater than on flyer frames, the spindles on the former being run as high as seven thousand revolutions per minute against twenty-eight hundred of the flyer spindles. This great difference in speed, however, is not wholly in favor of the cap frame as the yarn is much rougher and the percentage of *flyings* much greater than from a flyer frame.

The illustration, Fig. 139, shows a cap spinning frame. A comparison with Fig. 133 will show that the only difference between flyer and cap frames is in the spindles and caps. As will be seen in Fig. 139 the spindles do not extend to the bottom rail of the frame as is the case in the flyer frame. Moreover, they do not revolve

but are screwed into the spindle rail. The part that revolves is a tube or shell which fits inside the bobbin.

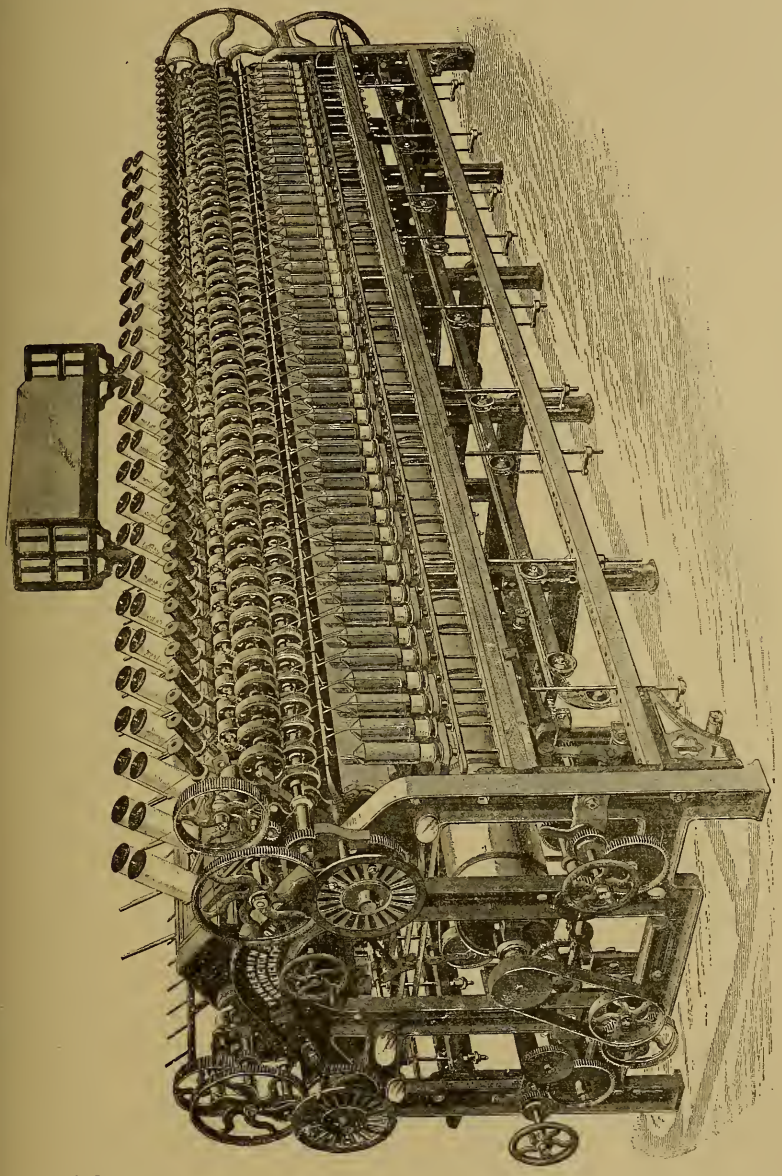


Fig. 139. Cap Spinning Frame.

The illustration, Fig. 140, shows the cap, spindle, and tube. The spindle 1 is stationary, as stated above, and is screwed into

the spindle rail 2. The tube 3 is a brass shell with an iron whirl 4 fastened at its lower end. The cap 5 is shown in section in the illustration. It fits on top of the spindle.

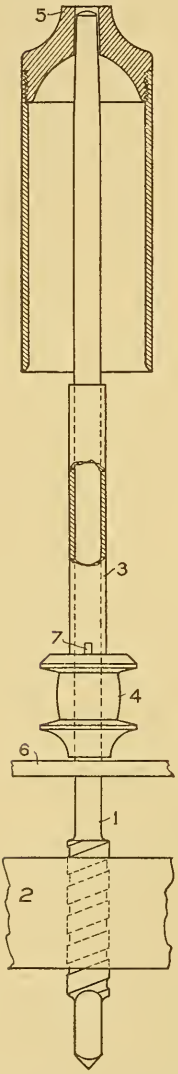


Fig. 140. Spindle and Tube with Sectional View of Cap.

Caps are made of steel and in various sizes and shapes to correspond with the sizes and shapes of various bobbins. There is a shuttle cap which is used with a bobbin for filling yarns; the bobbin must be made to fit the shuttle and of course the cap must be made to fit the bobbin. Caps should be large enough to admit the full bobbin inside and have about one-eighth of an inch to spare in diameter, and one-fourth of an inch in length.

The lifter plate (shown in Fig. 139, and 6 in Fig. 140) traverses up and down the spindle, carrying the tube and consequently the bobbin with it. The yarn is guided on the bobbin by the bottom rim of the cap, and the position of the bobbin is changed by the lifter plate. Fig. 141 shows a filling bobbin about half filled with yarn. A is the cap, B the bobbin, W the whirl, L the lifter plate, R the spindle rail, and S the spindle.

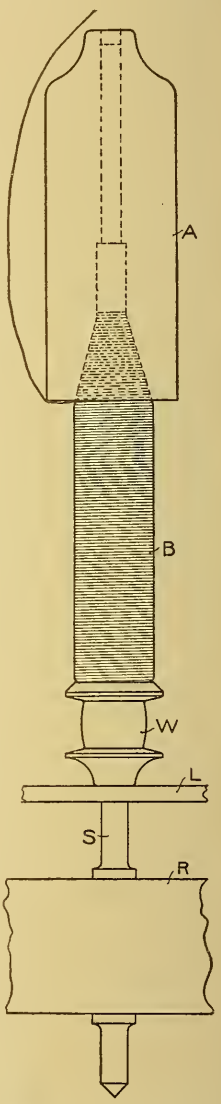


Fig. 141. Partially Filled Filling Bobbin on Cap Spindle.

The cap and bobbin for warp yarns are quite different in size and shape. The bobbin is usually double headed and both the bobbin and cap are of much

larger diameter than the filling or shuttle bobbin and cap. The illustration Fig. 142 shows a warp bobbin and cap. In filling these bobbins the lifter plate traverses from one head of the bobbin to the other.

Warp yarn is also spun on single head bobbins in the same manner as filling. The bobbins and caps are larger, however, to allow more yarn to be wound on the bobbin. This method is growing more popular as it eliminates the necessity of changing the lifter motion when changing from warp to filling.

Twisting. The tube rests on the lifter plate and revolves around the spindle, carrying the bobbin, which rests on the whirl, around with it. A groove is cut in the bottom of the bobbins which fits on a pin (shown at 7 in Fig. 140) placed at the top of the whirl. This very effectively prevents the bobbin from slipping.

The tube, with the bobbin, revolving around the spindle puts twist into the yarn. The yarn revolves around the bottom rim of the cap as it is wound on the bobbin. The cap remains stationary while the lifter plate travels up and down the length of the traverse and forms the shape of bobbin desired.

The tube and bobbin revolve in the same direction as the flyer spindles; *i. e.*, from left to right, and while putting twist in the yarn also wind it on the bobbin. If the bobbins are wound too soft there are two methods of making them hard: *first*, by increasing the speed of the spindles, and *second*, by lowering the spindle rails, for as the spindle is fast in the spindle rail, and as the cap is stationary on the spindle, it follows that as the spindle rail is lowered the bottom edge of the cap will be farther from the nip of the front rolls, and the drag increased in proportion.

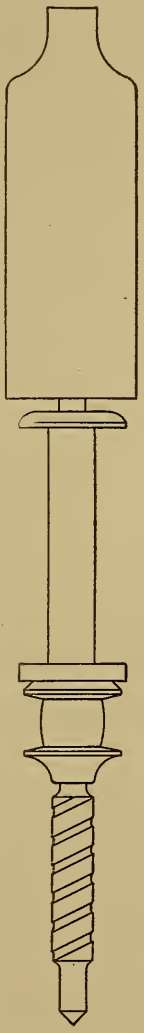


Fig. 142. Warp Bobbin and Cap.

The methods of calculating the draft and twist are the same on both cap and flyer frames so will not be repeated. The arrangement for drafting is identical on both frames, and while the method

of putting in twist is different, the bobbin instead of the flyer carrying the yarn around, it is only necessary to substitute the speed of the bobbin on cap frames for the speed of the spindle and flyer on flyer frames to find the turns of twist.

For example, to give a yarn twelve turns of twist per inch on the flyer frame, the flyer makes twelve revolutions while the front rolls deliver one inch of yarn. To give a yarn twelve turns of twist per inch on the cap frame, the tube and consequently the bobbin make twelve revolutions while the front rolls are delivering one inch of yarn. The amount of yarn wound on the bobbins is of course the same as delivered by the front rolls, less the small take-up caused by the twist.

While the production of cap frames is much greater than that of flyer frames there are some disadvantages. There is nothing to protect the yarn while it is being whirled around the cap at a speed of from six to seven thousand revolutions per minute. The friction against the air is so great that it raises the fibers on the yarn. In coarse counts this gives the yarn a very rough and hairy appearance, but in the finer counts this defect is not noticeable and the large production offsets all disadvantages.

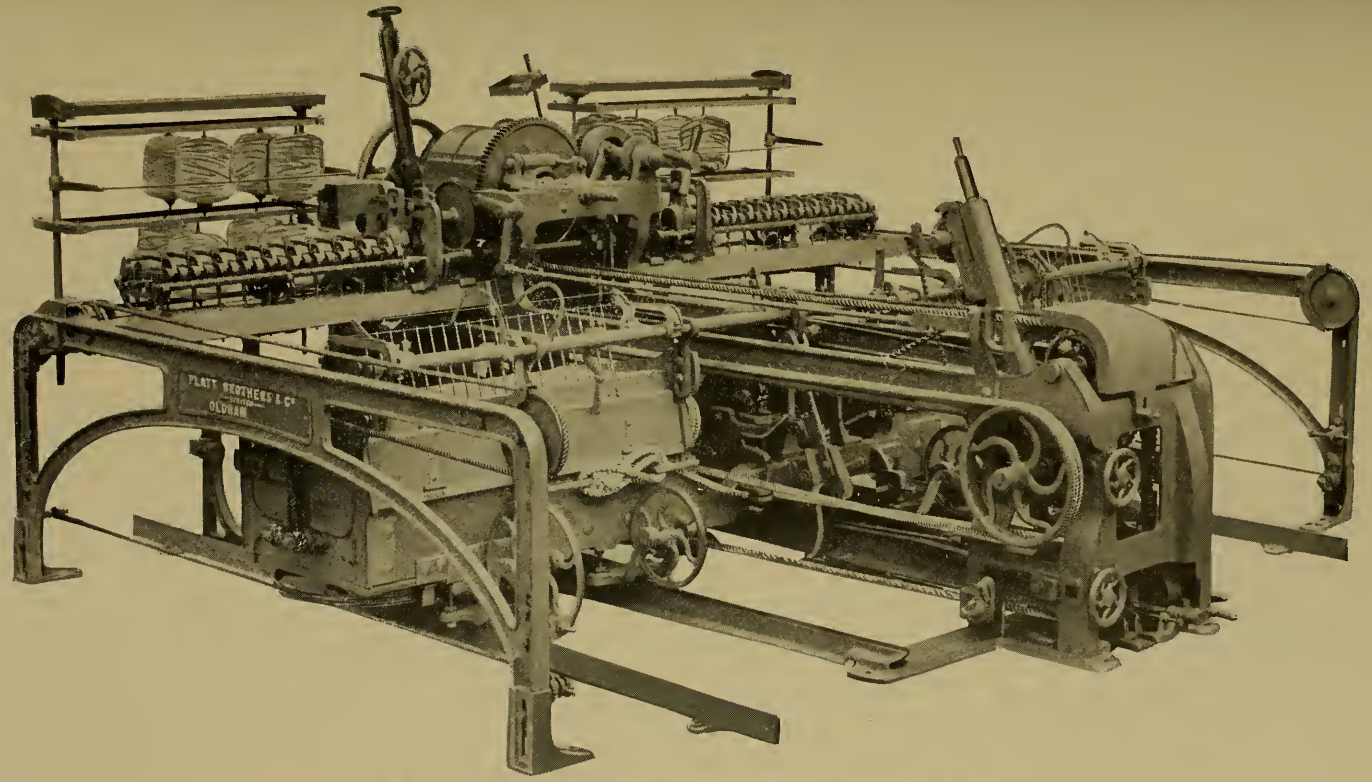
Owing to the method of winding the yarn on cap frames it is wound around the bobbin in the opposite direction from that of a flyer frame because, as it were, the bobbin drives the yarn before it and takes it up in the same way that it revolves.

Ring Spinning Frame. Ring Spinning is the newest of the systems for spinning worsted yarns, although it is almost universally used for spinning cotton.

The illustration, Fig. 143, shows a ring spinning frame and it will be noted that it very closely resembles the flyer and cap frames. The same operations are performed on all these machines but the methods of imparting twist and winding the yarn on bobbins, differ.

The method of drafting is the same as explained in connection with flyer spinning but after the yarn leaves the front rolls it is treated somewhat differently.

Twisting and Winding. The method of twisting the yarn and winding it on the bobbin is illustrated by Fig. 144. S is the spindle, R the ring, T the traveler, and B the bobbin. Y represents the yarn being delivered by the front rolls, and L is the ring rail.



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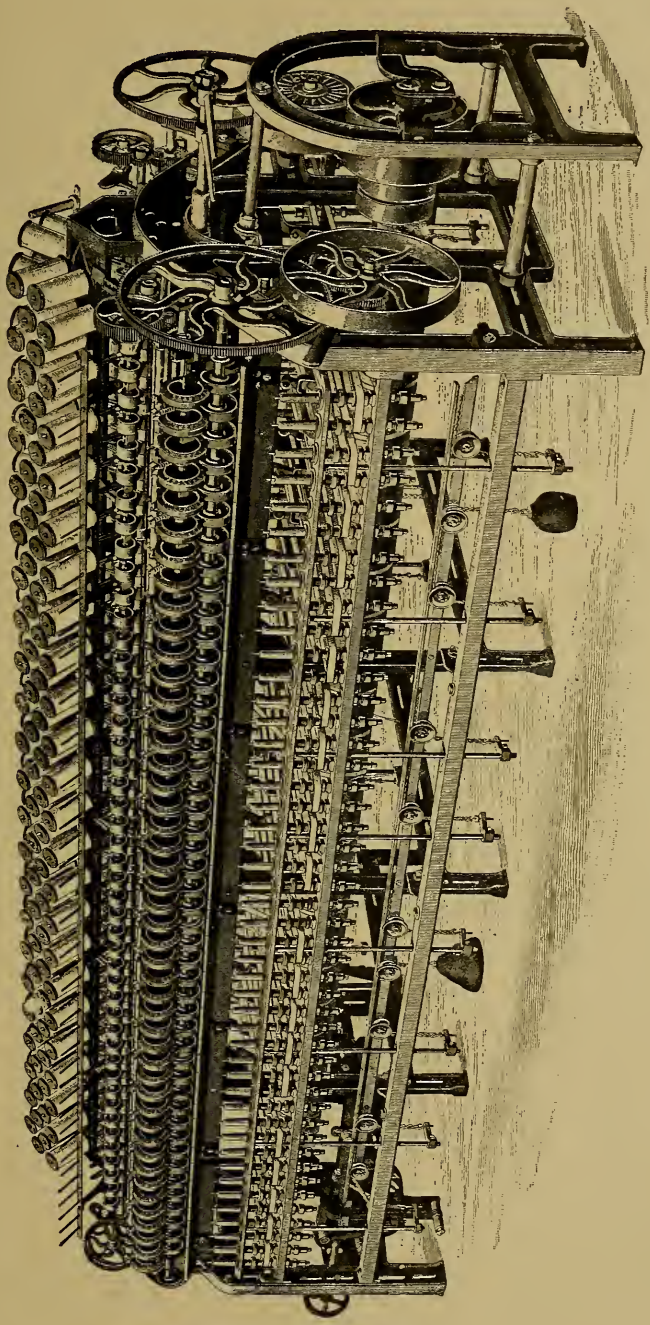


Fig. 143. Ring Spinning Frame

Fig. 145 represents a spindle for ring frames, W is the whirl which is fixed to the spindle, and A is the part upon which the bobbin rests. A pin, whose purpose is to drive the bobbin, is inserted into the solid part A. The bobbin being driven by the spindle puts in the twist.

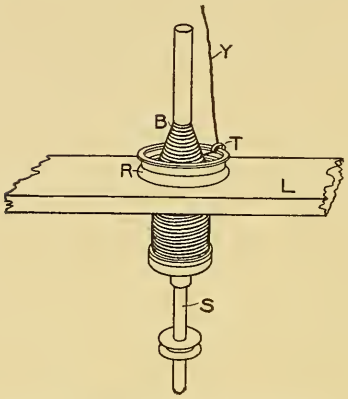


Fig. 144. Diagram Showing Relation of Bobbin, Ring, and Traveler.

The bobbins do not traverse up and down as on the cap and flyer frames for in this case the ring rail traverses up and down, guiding the yarn on the bobbins as desired.

The rings (Fig. 146) are made of steel and turned perfectly true, for any unevenness is a serious defect. They are fixed to the ring rail by a clamp (shown in Fig. 147) which holds them firmly in position.

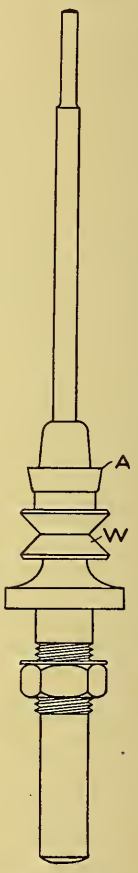


Fig. 145. Spindle for Ring Frame.

The top rim of the ring is provided with a flange (C, Fig. 146), around which the traveler runs. The traveler is a small, semicircular piece of tempered steel, with each end somewhat flattened so that it will not be pulled off the ring by the tension of the yarn. Fig. 148 shows an enlarged section of rings and travelers, and illustrates how the traveler is held on the ring by the flange.

Principle of the Traveler. The traveler receives its motion by being dragged around the ring by the yarn. As the yarn passes from the front rolls to the bobbin it is bent at right angles at the point when it passes through the traveler. Therefore all the twist is introduced between the traveler and the front roll. In fact, the traveler performs a double duty being the medium

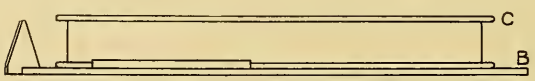


Fig. 146. Elevation of Ring.

through which the bobbin gives twist to the yarn, and winding the yarn on the bobbin.

The size and weight of the traveler must be adapted to the size of yarn being spun. This is necessary so that the revolutions of the traveler shall fall behind the revolutions of the bobbin enough to maintain a tension upon the yarn sufficient to wind the same length that is delivered by the front roll, less a small amount due to contraction on account of the twist.

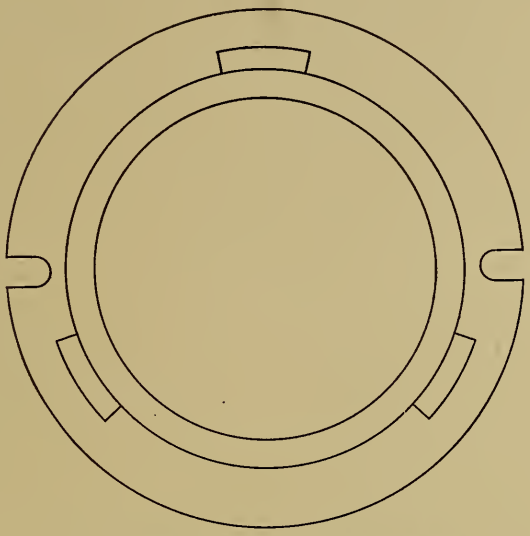


Fig. 147. Plan of Clamp for Fastening Ring in Ring Rail.

The smaller the diameter of the bobbin the more revolutions are necessary to wind the same length, and as the speed of the bobbin is constant it is evident that the tension on the yarn must relax and allow the traveler to fall behind the bobbin and cause more yarn to be wound. This may be understood by studying the two diagrams in Fig. 149. In these illustrations R is the ring, T the traveler, S the spindle, F the full bobbin, and E the empty bobbin.

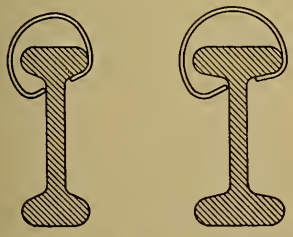


Fig. 148. Enlarged Section of Rings and Travelers.

The yarn is represented as passing through the traveler by the line Y. With the full bobbin (Diagram B) the pull of the yarn is nearly parallel with the ring and the traveler is rotated with comparative ease, but with the empty bobbin (Dagram A) the pull of the yarn approaches a radial line and is not as well suited to rotate the traveler.

We will assume that the empty bobbin is three-quarters of an inch in diameter (2.35 inches circumference) and that the full bob-

bin is one and three-quarters inches in diameter (5.49 inches circumference). If the traveler is held stationary and the empty bobbin given one revolution there will be wound 2.35 inches of yarn, while with the full bobbin one revolution will wind 5.49 inches of yarn.

If the rotations of the traveler were not retarded, it would travel around the ring a distance equal to 2.35 inches for an empty bobbin and 5.49 inches for a full bobbin, and as each rotation of the traveler gives one twist to the yarn a considerable difference in the twist

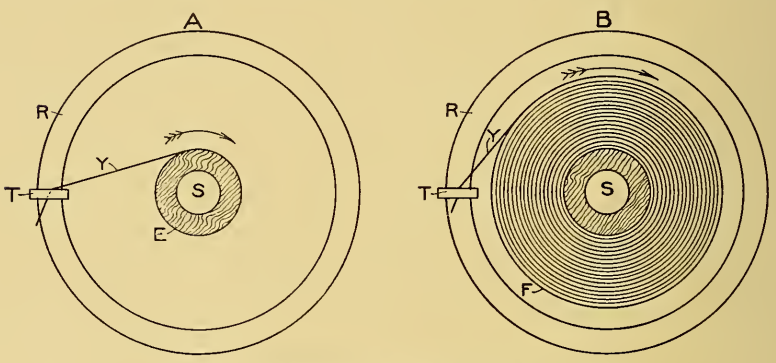


Fig. 149. Diagram Showing Difference in Tension.

per inch will be produced, but as the traveler falls behind the bobbin only enough to cause the yarn to be wound, the difference in the twist is not appreciable.

If the bobbin makes one hundred revolutions and in the same time the front rolls deliver ten inches of yarn the twist may be called ten turns per inch. The empty bobbin will have to make 4.25 revolutions.

$$\frac{10}{2.35} = 4.25$$

The traveler will make 95.75 revolutions, or the speed of the bobbin less the number of revolutions necessary to wind the yarn.

$$100 - 4.25 = 95.75$$

At each rotation of the traveler the yarn receives one turn of twist, so the actual twist is 9.57 turns per inch.

$$95.75 \div 10 = 9.57$$

With the full bobbin 1.84 revolutions are necessary to wind the ten inches of yarn delivered by the front roll.

$$\frac{10}{5.49} = 1.84$$

The traveler will then make 98.16 rotations.

$$100 - 1.84 = 98.16$$

This gives 9.81 turns of twist for each inch of yarn.

$$98.16 \div 10 = 9.81$$

Thus the difference in twist per inch between a full bobbin one and three-fourths inches in diameter and an empty bobbin three-fourths of an inch in diameter is the difference between 9.81 and 9.57, or .24 of one turn.

The spindle and bobbin cannot vary in speed as the bobbin is driven by the pin on the spindle. It is the duty of the traveler to wind the yarn on the bobbin and to regulate the drag. The heavier the traveler used the more drag is required to pull it around and consequently the harder will the yarn be wound on the bobbin. This makes it possible to spin successfully a wide range of counts.

WOOLEN SPINNING

Woolen yarn is spun on a machine termed the *mule,* which draws out the roving, twists the yarn, and winds it on bobbins. The modern mule is a complicated machine, but the principles are the same as in the old spinning wheel where the thread was drawn out by hand. The present self-acting mule may draw out and twist as many as four hundred threads at one time.

Before reaching the spinning room the wool passes through a set of cards and is made into the form of roving as explained in Part 11. This roving is wound on jack spools and carried to the mule.

The success of the spinning operation depends to a large extent upon the care and thoroughness exercised in the carding room, for the more even the roving received from the card, the stronger and smoother the yarn made from it. Uneven roving will make uneven, twitty yarn, and this defect cannot be corrected in spinning. The spinning process does, however, have a tendency to even the inequalities, as it were, for the twist sets in the thin places as the yarn is

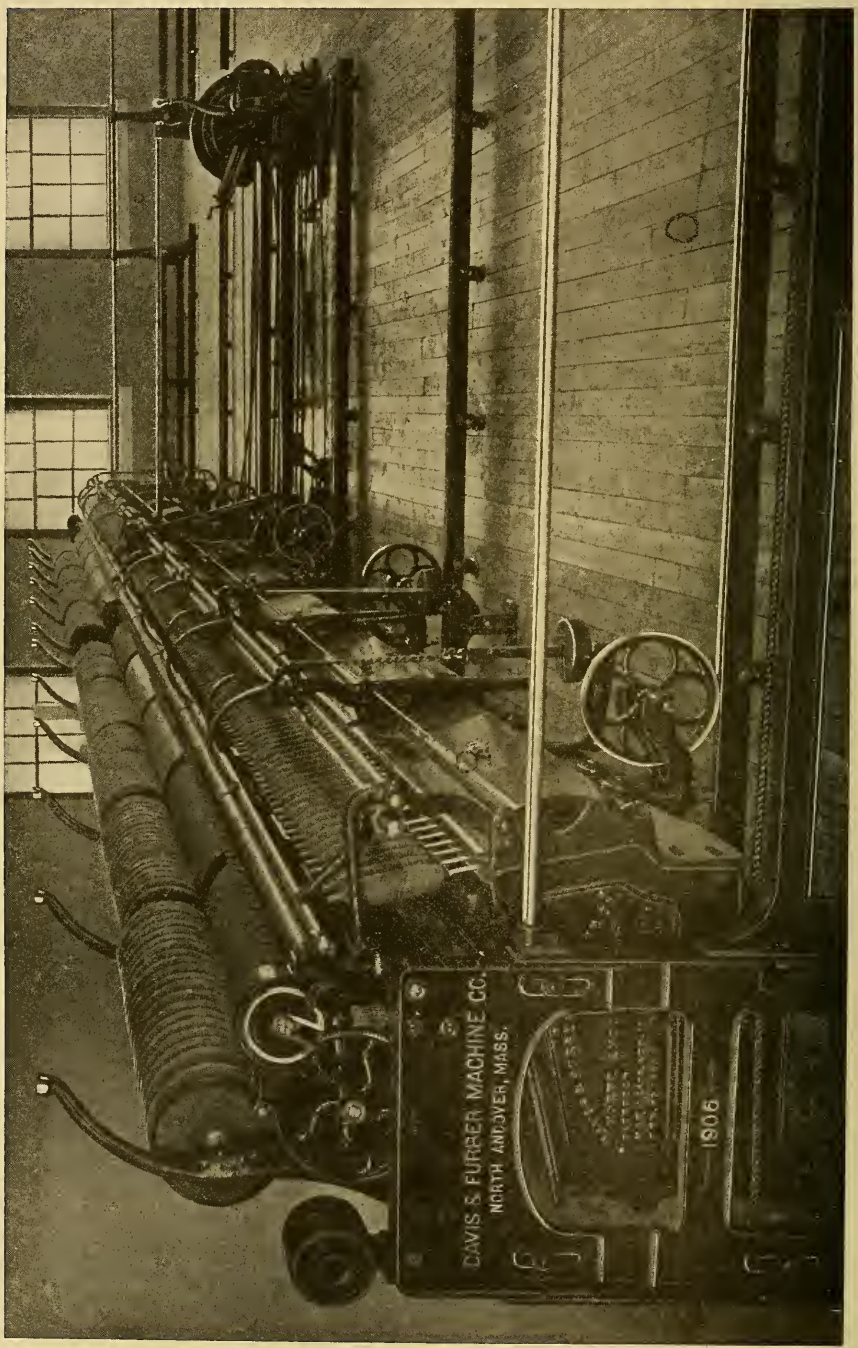


Fig. 150. Davis & Furber Mule.

being drawn, which causes the thicker untwisted places to be drawn out to more nearly the correct size. It is, however, a very poor policy to depend upon the spinning room to make up for the defi-

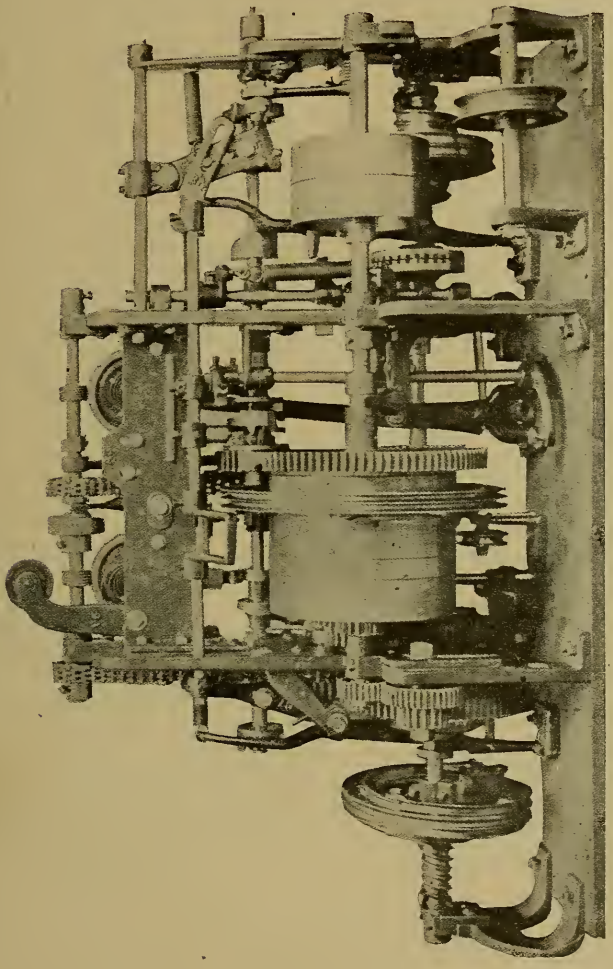


Fig. 151. Back View of Head Motion, Johnson and Bassett Mule.

ciencies of the card room, and is the cause of a large amount of bad yarn and waste.

Operation. When a jack spool is placed in a mule and the machine started the action is briefly as follows: A quantity of roving is unwound (depending upon the size of the yarn into which it is to be spun) from the spool, drawn and twisted to the proper size, and

wound on bobbins to facilitate handling in subsequent operations.

The machine which performs the work consists primarily of two parts, each one of which is dependent upon the other for the ultimate accomplishment of the purpose of the machine. These parts are known as the *head stock* and the *carriage.*

Head Stock. The head stock receives power from the main shaft, and controls, either directly or indirectly, all the motions of the

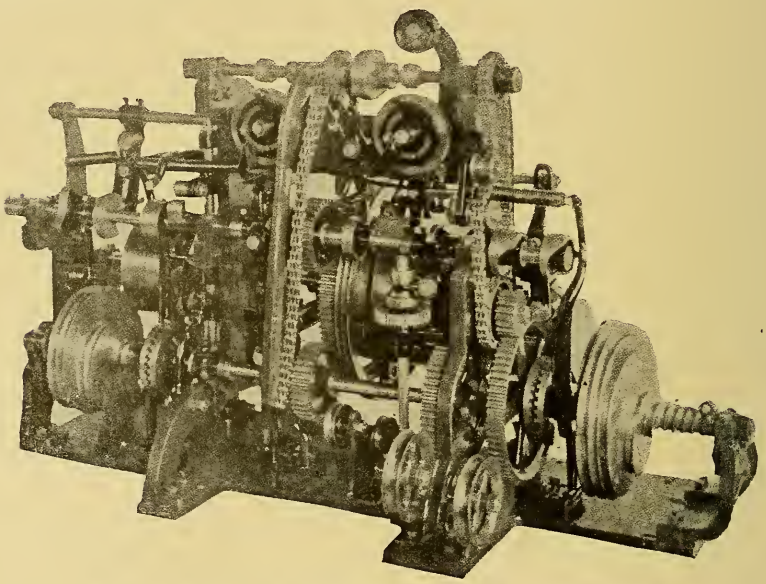


Fig. 152. Front View of Head Motion, Johnson & Bassett Mule.

carriage and delivery rolls. The illustrations, Figs. 151, 152 and 153, show three views of this part of the machine.

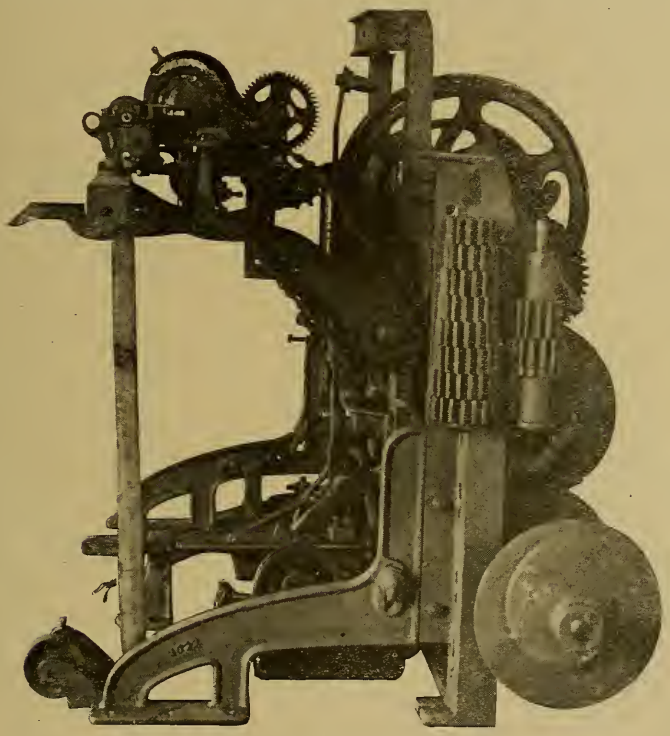
Carriage. The carriage, which travels in and out automatically, is controlled by the head stock, and draws, twists, and winds the yarn on bobbins placed on the spindles. To obtain a better idea of the carriage careful reference should be made to Fig. 150, which gives a good idea of the machine in general.

The illustration, Fig. 154, is a line drawing of the jack spool drawing-off rolls, spindle, carriage, etc., and shows their relation to one another. The jack spool M, on which the roving is wound, is placed on the drum L, the ends being passed through the guide K and between the drawing-off rolls G and H, and made fast to the

bobbin C on the spindle S. The two bottom delivery rolls are geared to the drum L being driven in turn from the head stock.

When the delivery rolls are revolved, the drum L is turned, unwinding roving from the spool M. The top delivery roll is made in sections covering two ends and is driven by friction from the bottom rolls.

The spindle S, which is slightly inclined toward the delivery rolls, is supported by a step board at the base B^5 and by a collar



Fig, 153. Side View of Head, Davis & Furber Mule.

board B^6. A short distance above B^5 a small grooved pulley B, known as the *whirl,* is placed. Passing around this whirl and around cylinder A is an endless band which transmits power from the cylinder to the spindle. Each spindle on the machine may have a separate band, or a number of spindles may be driven by a single band passing alternately around the spindle and drum, then around a pair of binders back to the starting point. The spindles and drum cylinder

are carried by a frame carriage Y mounted on a casting X which in turn is supported by the wheels E which run on the track F. The tracks are to facilitate the movement of the carriage, their number depending upon the length of the machine.

At the commencement of a draw the carriage is in, the top of the spindles being just below and within approximately one inch of the delivery rolls G and H. Simultaneously with the delivery of roving from the rolls, the carriage commences to draw away from the head, and the spindles commence to revolve.

The speed of the carriage and the surface speed of the rolls are about the same till the required amount of roving has been given off,

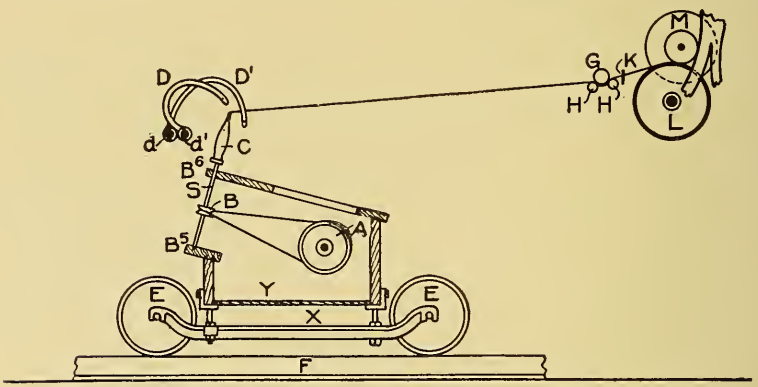


Fig. 154. Diagram Showing End View of Carriage, Delivery Rolls, etc.

then the rolls stop, the carriage continuing till the end of the draw is reached; a distance of about seventy-two inches from the drawing-off rolls. During the latter part of the operation the roving is drawn and twisted, while during the first part, till the delivery rolls were stopped, the roving was simply being twisted. The amount of roving given off depends upon the stock and the size of yarn to be spun.

The reason for inclining the spindle towards the delivery rolls is to allow the yarn to slip over the end of the bobbin at each revolution of the spindle during the twisting. The revolving of the spindle causes the yarn to assume a position at right angles to the bobbin. The top of the bobbin being below the delivery rolls, the yarn rises in a series of spirals as the spindles revolve, slipping over the end of the bobbin at each turn.

Fig. 155 illustrates this point. The yarn tends to rise along line X-Y till the point X should be reached when it would tend to wind around the spindle. The point of the spindle being below the delivery rolls G and H the yarn slips off instead of winding up; a twist being put into the yarn, for every revolution of the spindle. This continues till the required number of turns has been put in the yarn, at which time the spindles are stopped.

Some machines are fitted with an attachment whereby the speed of the cylinder A is increased as soon as the carriage reaches

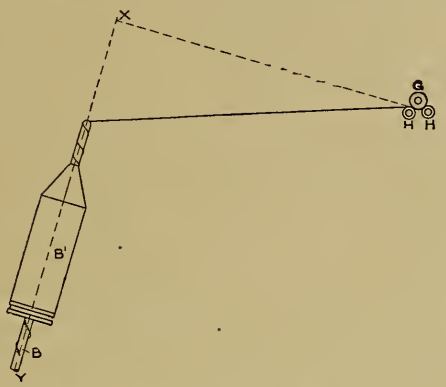


Fig. 155. Diagram Showing Angle of Spindle.

the end of the stretch. This is done for the purpose of putting in the twist in as short a time as possible.

Fallers. Attached to the outside of the carriage, a few inches from the center of the bobbins, are two shafts or rods d and d^1. Fastened to these rods are the fallers D and D^1, through the ends of which pass heavy steel wires. The longer or *tension faller* is so placed that the wire is always below the yarn, while the shorter or *winding faller* carries the wire above the yarn.

As soon as the required amount of twist has been put in the yarn, the spindles are reversed for a few turns. With the reversal of the spindles, the winding faller descends and the tension faller ascends for the purpose of keeping the proper strain on the yarn.

Following the change of the fallers, the drawing in of the carriage commences, the spindles revolving so as to wind up the slack yarn. As the carriage moves in, faller D ascends, allowing the yarn to wind on the bobbins slowly and in close spirals. In the meantime

the tension faller descends, its function being to keep the yarn under the same tension at all times. When the carriage strikes in, the fallers change, assuming their former position.

This cycle of movements, consisting of the delivery of the roving, drawing and twisting incidental to the running out of the carriage, backing-off and winding up of the yarn as the carriage runs in, completes what is known as a *draw*.

So far the machine has been dealt with in a general way, no attempt being made to show how and when the various changes are made. The actions of the various parts will now be taken up in addition to their relation to the action of the whole machine. Close attention must be paid in order to carry in mind the functions of the various parts as well as the order in which they occur. During a *draw* a certain part may perform several different functions which will tend to make the machine harder to understand.

Details of Head Stock. In dealing with the parts in detail, the head stock first demands our attention, as this is the part that receives the power and is the source of all the changes. The illustration, Fig. 156, is a sectional view of the principal parts.

The main shaft F carries four pulleys, F^1, F^2, F^3, and F^4; two grooved pulleys F^5 and F^6; two gears F^7 and F^8; and a bevel gear F^9. F^1 is a loose pulley running on a sleeve which in turn is loose on the shaft. F^2 is connected by the sleeve mentioned above to the gear F^8 which controls the backing-off and drawing-in motions. F^3 and F^7 are fastened to the shaft and control the drawing out of the carriage. F^4 and the grooved pulley F^5 are attached and run loosely on the shaft. They control the accellerated speed. The grooved pulley F^6 is fast to the shaft and, when the belt is on F^3, drives the spindles during the delivery and drawing of the roving; *i. e.*, till the carriage has reached the end of the stretch. F^9 is a bevel gear attached to the shaft and drives the twist motion.

To Operate Carriage. To start the mule, the carriage being in and the belt on the loose pulley, the shipper handle is thrown backward, forcing the belt on F^3, or drawing-out pulley, which being fast to the shaft drives F^6, F^7 and F^9. On a stud and meshing with F^7 is a gear F^{10}. Fast to this gear is a gear F^{11} which meshes with a gear F^{12} which is loose on the drawing-out shaft G.

Fast to F^{12} is part of a clutch F^{13}, which is made to operate with

the part F^{14}. F^{14} slides on a key set into the shaft G. Through the above pulleys, gears, and clutch, power is transmitted to the shaft G which carries the drawing-out scroll G^1. When the shaft revolves the rope G^2 (Fig. 157) is wound up on one side of the scroll G^1 and the rope G^3 is unwound from the other side.

G^2 is attached to the carriage at G^5, passing around the binder pulley G^4 and then to the scroll. G^3 is a tension band whose purpose

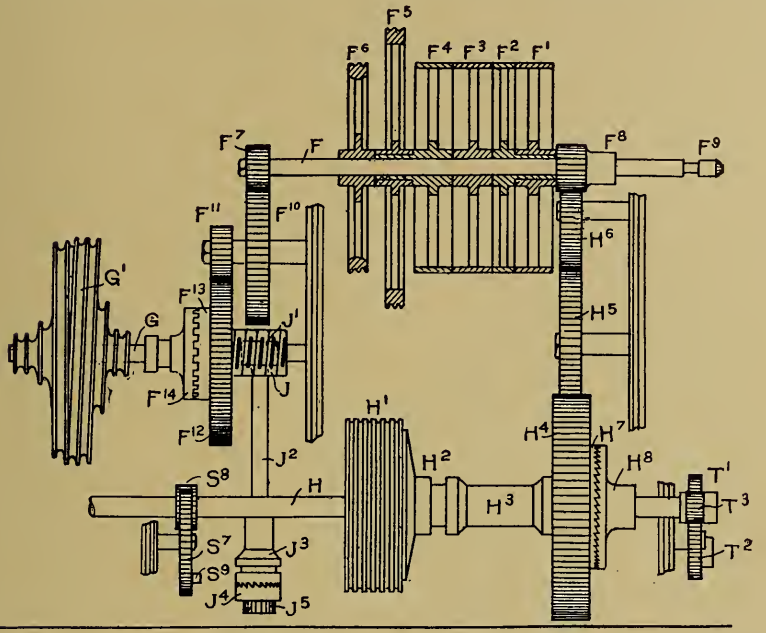


Fig. 156. Sectional View of Head Stock.

is to keep the carriage running out steadily, and prevent it from overrunning the drawing out rope G^2. The revolving of the scroll G^1 serves two purposes; it winds up the rope G^2, thus drawing out the carriage, while the unwinding of G^3 keeps the carriage steady.

To ensure the best results in drawing and spinning, the carriage must leave the head at a speed equal to that of the delivery rolls. When these stop, the speed of the carriage must slacken and the combined twisting and drawing takes place. The variable speed thus required is obtained by means of the draft scroll G^1 (Figs. 156 and 157.)

When the shaft G starts to revolve, the carriage is given the

necessary speed to keep the roving, as it is delivered from the rolls, at the required tension, because the rope is at first wound around the largest diameter of the scroll. But as the carriage is drawn out, the rope commences to wind down to the smaller part of the spiral, necessitating the slowing down of the carriage. The slowing down takes place as soon as the delivery rolls stop, and aids in the drawing of the roving.

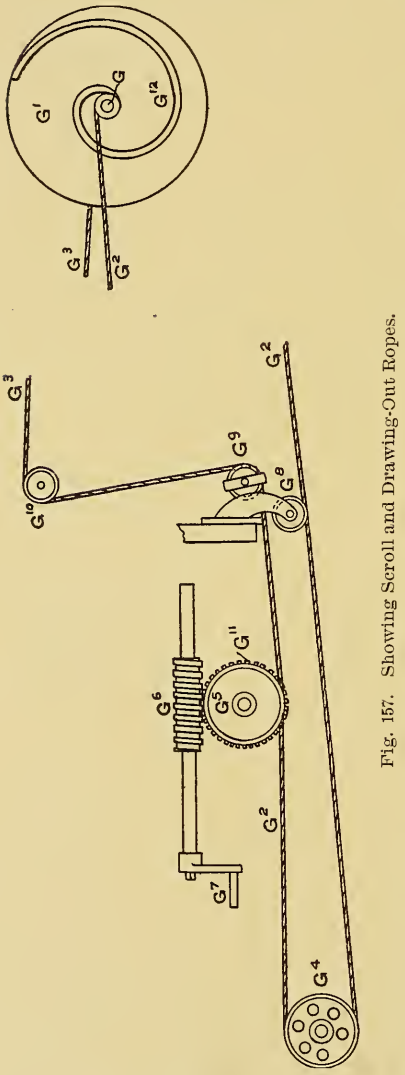


Fig. 157. Showing Scroll and Drawing-Out Ropes.

Squaring Bands. The power to draw out the carriage being applied to the middle, the ends would have a tendency to drag if some device were not used to prevent this.

Attached to the underside, and running from end to end of the carriage, is a shaft, having a drum or flanged pulley attached at the middle and ends. Around these drums but wound in the opposite direction are two ropes, their ends being made fast to castings screwed to the floor, one under the roller beam and the other just beyond the extreme stretch of the carriage. As the carriage is moved, one rope winds up and the other unwinds, and as all the pulleys are fast to the same shaft, they turn at equal speeds, thus drawing all parts of the carriage in or out with equal speed. It is necessary to keep the ropes tight to ensure the best results. This shaft is known as the *squaring shaft*, and the ropes are known as *squaring bands*.

Simultaneously with the shipping of the belt to the third pulley F^3, which causes the carriage to be drawn out, the delivery rolls and roving are set in motion, receiving their power from gear F^{12} of the

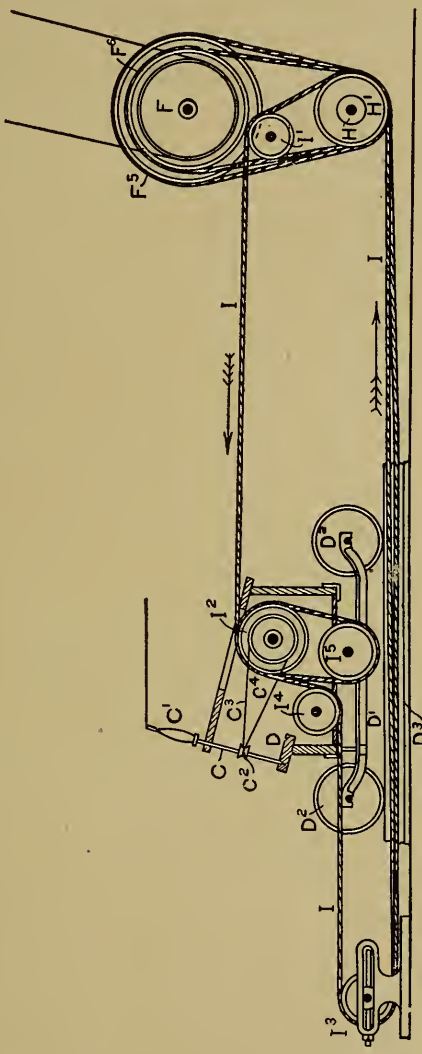


Fig. 158. Diagram Showing Method of Driving Carriage and Spindles.

train that drives the drawing out scroll. (Fig. 160.)

While the carriage is being drawn out, the spindles are twisting the roving, being driven from the cylinder C^4 which in turn is driven

by a rope known as a rim band (I, Fig. 158) which passes around the grooved pulleys F^5 and F^6 on the shaft F.

Pulley F^3, or drawing-out pulley, and grooved pulley F^6 are fast to the shaft, therefore, pulley F^3, in addition to drawing out the carriage, turns the spindles during the same period. While the belt is on the third pulley, grooved pulley F^5 is simply a follower as it is loose on the shaft.

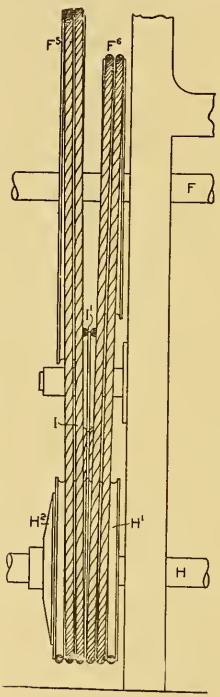


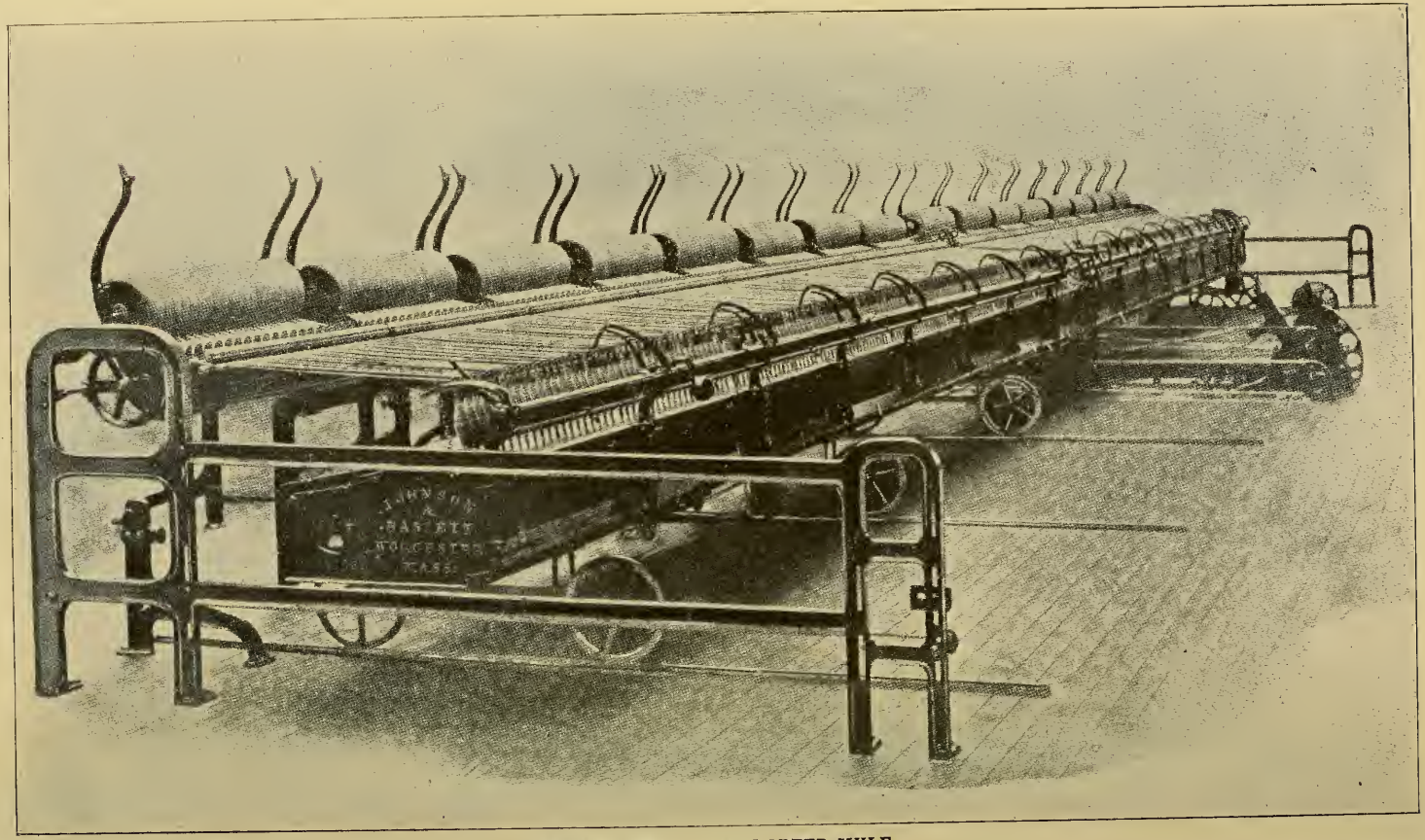
Fig. 159.

Accelerated Speed. As soon as the carriage reaches the end of the stretch the belt is forced to the fourth or accelerated speed pulley F^4 which is fast to the grooved pulley F^5. When this occurs F^6 ceases to drive the spindles, becoming a follower, while the larger grooved pulley drives the rim band, and in consequence of its increased size the cylinder C^4 and the spindles are driven faster. By this method a larger number of turns of twist are put in, in a shorter time.

The band passes over pulley I^2 on the cylinder shaft, around binder I^5, over I^2, and under binder I^4, then around binder I^3, which is fast to the floor, and pulley H^1, which is fast on the drawing-out shaft. Next it passes around the pulleys F^5 and H^1, back over F^5 and H^1, then over the binder I^1 and back to the carriage again, going around the pulleys the second time, except that it passes over grooved pulley F^6 twice instead of over F^5, finally coming out over binder I^1. (See Fig. 159.) This is known as a double rim band. Pulley I^2 is fast to the shaft which carries the cylinder C^4, and the spindles revolve with the cylinder as they are connected by band C^3.

The rim band and spindles always go in the same direction except during the backing off, at which time they are reversed, owing to the fact that the pulley H^1, on the drawing-in shaft, drives the band in the opposite direction. This is done to unwind some of the yarn in order to allow the fallers to change preparatory to winding the yarn on the bobbin as the carriage runs in.

Easing-Up Motion. Yarn *takes-up* or contracts in length



FRONT VIEW OF HIGH SPEED MULE

Johnson & Bassett

while being twisted, and in order not to overstrain it the carriage is drawn in slightly towards the head while the belt is on the fourth or accelerated speed pulley. This easing-up motion, as it is called, is accomplished as follows: When the carriage reaches the end of the draw, a pin drops into a slot in a rod, which is connected, by means of rods and levers, to the rack L^6, Fig. 160. Simultaneously with the dropping of the pin into the slot the belt is shipped from the third, a drawing-out pulley, to the fourth or accelerated speed pulley, which is free on the shaft.

The band I passes over the grooved pulley F^5 which is fast to the fourth pulley. It also passes over the grooved pulley F^6, which

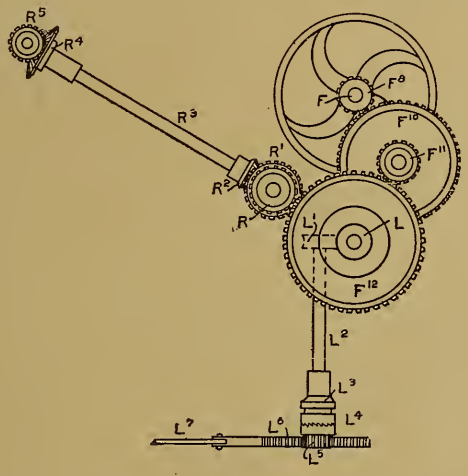


Fig. 160.

is fast to the shaft F, thus causing it to turn, and drives through F^8, F^{10}, F^{11} and F^{12}. On the shaft L to which F^{12} is fastened is a worm which meshes with a gear L^1 on the end of the upright shaft L^2. Sliding on a pin on the lower end of the shaft L^2 is one half of a clutch L^3, which meshes with the clutch L^4, which is fast to the gear L^5, meshing with rack L^6.

Attached to L^6 is a rod L^7 which is fastened to a lever one end of which is attached to the floor. Fastened to the free end of the lever is a rod which is slotted at the end and into which the pin, mentioned above, drops, forming the connecting link between carriage and rod.

The reason for attaching the rods to a lever is to allow a greater or less amount of easing-up.

As soon as the belt is shipped to the fourth pulley; *i. e.*, when the

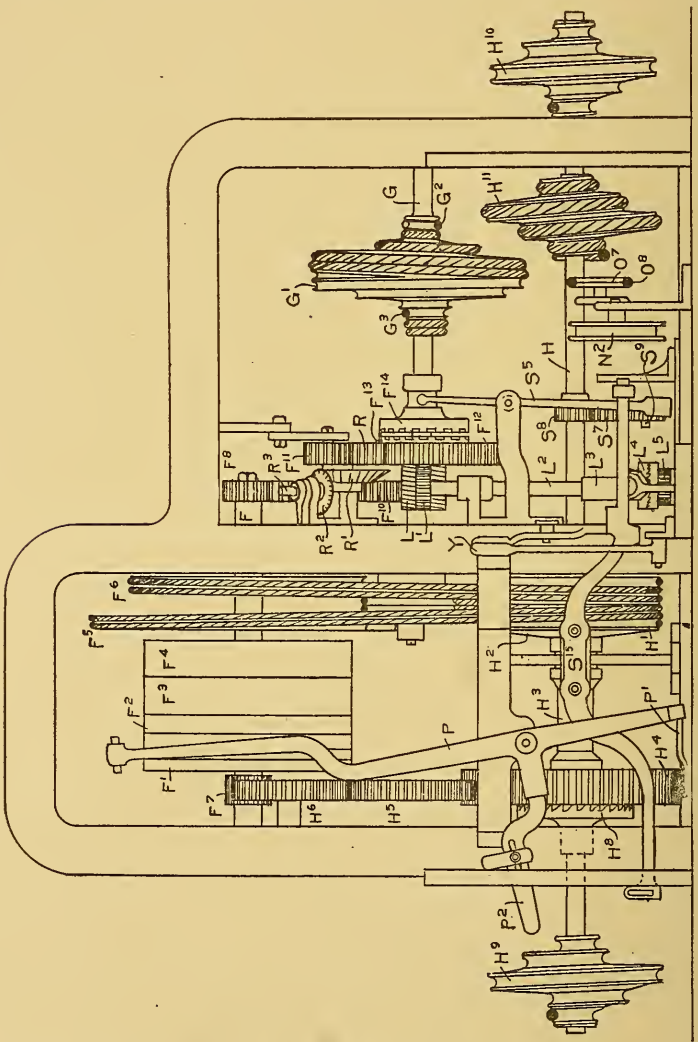


Fig. 161. Details of Head Stock.

carriage reaches the end of the draw, the carriage is drawn in slowly by receiving power through the gears and levers just mentioned.

Backing-Off. When sufficient twist has been put in, the yarn is ready to be wound on the bobbin, and the motion known as *backing-*

off takes place. This consists of unwinding a few coils of yarn, and is accomplished by reversing the spindles. In order to do this, the rim band must be reversed, this being done in the following manner:

The belt is shipped to the second or drawing-in pulley F^2 at the same time forcing the friction clutch H^2, which up to this time has been in a neutral position, into clutch H^1. (Fig. 156.) Pulley F^2 and gear F^8 are connected by a sleeve and the power is transmitted through F^8 to H^6, H^5, H^4, sleeve H^3, friction disc H^2, to pulley H^1, which causes the band to run in the opposite direction, reversing the spindles. While the spindles are being reversed, the winding faller descends to guide the yarn to the bobbin and the counter faller ascends to keep the tension on the yarn.

Drawing-In. After the backing-off has taken place, the carriage is ready to run in. The friction clutch is thrown out of contact and the clutch H^7 (Fig. 156) is forced into contact with the clutch H^8 fast to the drawing-in shaft H. The belt is still on the second or drawing-in pulley F^2, driving through the train of gears previously mentioned. The easing-up motion is stopped when the backing-off takes place.

As soon as clutch H^7 meshes with H^8, the drawing-in shaft commences to revolve. Fast to both ends of the shaft are scrolls H^9 and H^{10}, the ropes being connected directly to the carriage and are the ones that draw it in. Fast to this shaft is another scroll, the rope passing from it around a binder in front of the carriage and then back to the carriage. This rope is known as a *check band* and is used to prevent the carriage from overrunning as it is being drawn in.

The check band is wound around the scroll in the opposite direction to that in which the drawing-in ropes are wound, consequently the winding up of the drawing-in ropes unwinds the tension band.

The drawing-in scrolls are made large in the middle and small at both ends, the object being to start the carriage without undue strain, increase its velocity, and then gradually ease it down till it strikes in, thus obtaining the maximum speed with the minimum of power and strain. While the carriage is running in, the spindles are revolving, winding the yarn on the bobbin. This motion is controlled by a mechanism known as a *quadrant*, which gradually reduces

the number of revolutions of the spindles in proportion to their ever increasing size.

Quadrant. At each stretch there are seventy-two inches of yarn to be wound on the bobbin. A large number of revolutions is necessary to wind up this yarn when the bobbins are empty, than when they are nearly full. This variation in speed being necessary, the quadrant is used, as the rim band has a constant speed.

Referring to Fig. 162 it will be seen that one end of the quadrant chain M^3 is fastened to the floor by M^8, then passes around the grooved pulley M^2 and the drum M^4. A plan of the drum and winding clutch is given at the upper right hand of the illustration.

The drum M^4 is geared by means of M^5 to the gear M^{11} which in turn meshes with M^6 which is loose on the shaft. Fast to the gear M^{11} is one-half of a clutch M^9, and sliding on a key in the shaft is a clutch M^{10}. When the carriage is drawn in the clutch M^{10} is in contact with M^9, and the unwind of the chain from the drum M^4 causes the spindles to revolve and consequently to wind up the yarn.

Referring to Fig. 162 it will be seen that the chain N passes over the sprocket N^1, around N^2 and back to the carriage, and that any movement of the carriage will cause N^1 to revolve. Fast to N^1 is a gear which meshes with the teeth N^4 on the inside of the flange N^5 Thus as the carriage runs in, the quadrant M is rotated on its axis, being turned by gear N^3 attached to N^1. The drawing out of the carriage reverses the action, causing the quadrant to turn back.

It will be noticed that the pulley M^2 is attached to a block made to run up and down on a differential screw by means of a pin working in the thread. When the mule is started up with an empty set of bobbins, the pulley M^2 is wound to the bottom of the screw M^1. When in this position, being very near the axis of the quadrant, the maximum amount of chain will be wound from the drum M^4 causing the spindles to revolve the greatest number of times. This is due to the fact that the length of chain unwound will be nearly equal to the stretch; *i. e.*, seventy-two inches.

If pulley M^2 were wound to the top of the screw, it will be readily seen that less chain will be unwound when the quadrant turns forward than when the pulley was at the bottom of the screw. This decreased amount of chain being unwound, means less revolutions

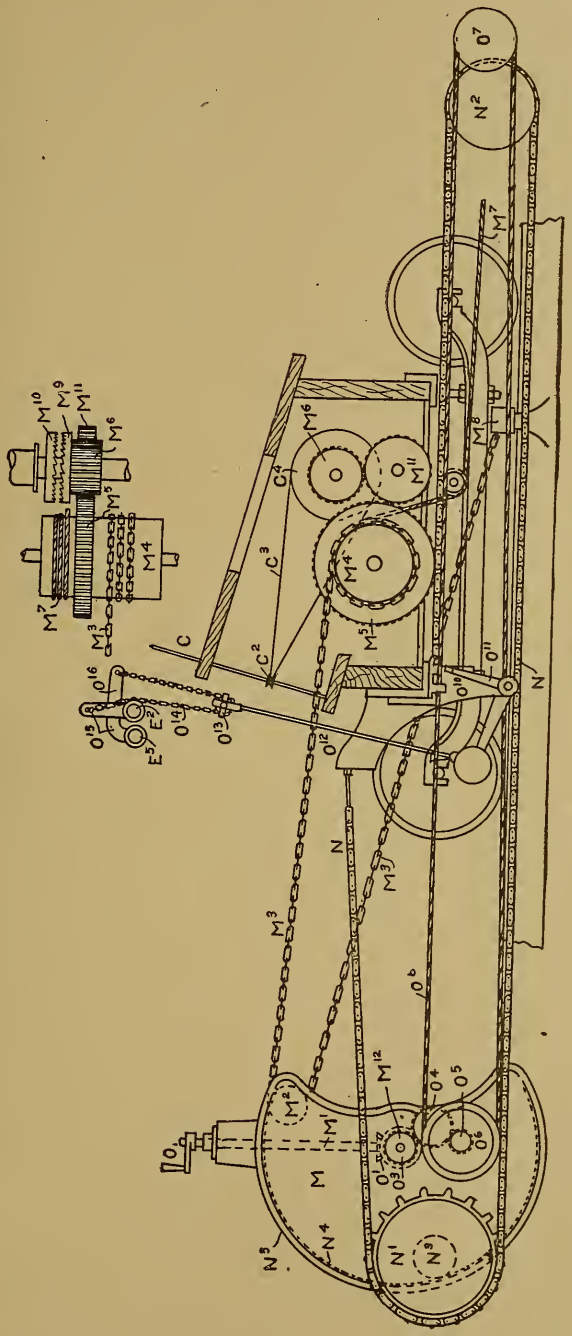


Fig. 162. Details of Quadrant, Chain, etc.

of the spindles. This shows how the number of revolutions may be varied.

The method of turning the screw, thereby raising M^2, is as follows: Attached to the bottom of M^1 (see Fig. 163) is a bevel gear which meshes with another bevel gear attached to gear O^3, which receives its power from pulley O^6 through gears O^5 and O^4. Passing around pulley O^6 is a band O^8, which passes under the carriage and around pulley O^7, then back to the starting point, forming an endless band which passes just below casting O^{10}. The elbow lever O^{11} is so attached to the carriage, that unless the weighted end is held up, the other end will force the rope O^8 against the casting O^{10} where it will be held firmly as the carriage runs in, thus causing the pulley O^6 to revolve, which turns M^1 thus raising M^2.

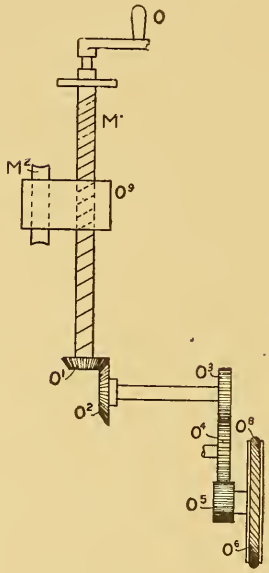


Fig. 163.

The position of M^2 is regulated by the tension on the yarn. As the bobbin increases in size, the tension on the yarn has a tendency to increase, due to the spindles turning the same number of revolutions while the bobbin was increasing in size. This increased strain on the yarn holds the counter faller down.

Hanging on a chain, one end of which is fast to a lever O^{15} on the winding faller shaft, the other end being fastened to a lever O^{16} on the counter faller, is a rod O^{12}, the other end of which is fast to the elbow lever O^{11}. The tightening of the yarn keeps the faller down, allowing the weighted end of the elbow lever to drop, thus forcing the rope O^8 against the casting O^{10}. As the carriage is drawn in, the rope being held tight turns the pulley O^6 thus raising M^2, and thereby causing less chain to be unwound from the drum. This causes the spindles to make fewer revolutions and relieves the tension.

After the base of the bobbin has been formed, the same number of turns are required to wind up the yarn spun at each stretch, so the spinner usually loops the chain O^{14} over one of the levers so that

there is no chance for the elbow lever to come in contact with the band O^8. This device is used only during the formation of the base of the bobbin, and during this time M^2 has been wound to the top of the screw M^1.

The reason for having a differential thread on the screw is as follows: One layer of yarn on an empty bobbin causes a greater increase in proportion to the diameter of the spindle, than a layer on a nearly completed bobbin, therefore, the number of revolutions must vary in proportion to the ever increasing diameter of the base. For this reason the pulley M^2 is raised ever decreasing distances as the carriage moves in, controlled by the differential pitch of the screw, thus unwinding less chain at each draw.

After the base of the bobbin has been formed and M^2 has been wound to the top of the screw M^1, the quadrant controls the speed and number of revolutions of the spindles independent of the screw. As the yarn is wound on an ever rising cone, with no change of diameter, no change in the number of revolutions is necessary.

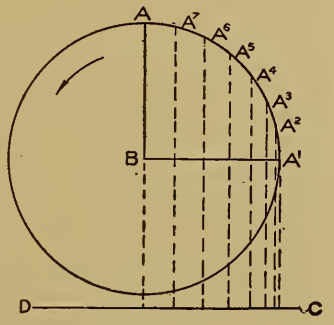


Fig. 164.

When the mule backs-off the yarn is unwound to the top of the cone of yarn, the winding faller descends to this point, the quadrant being clear back. When the carriage commences to run in, the quadrant revolves toward the retreating carriage, the winding faller meanwhile descending till it has reached the bottom of the cone. When this point is reached, the quadrant has reached the perpendicular.

As the yarn is now to be wound on the bottom of the cone, the spirals gradually rising towards the top, the speed of the spindles must steadily increase as the diameter decreases, in order to take up the yarn. This variation is controlled by the throw of the quadrant, which is about forty-five degrees.

In order to show how this throw affects the speed of the spindles the diagram, Fig. 164, has been prepared. Suppose on the outward throw, the pulley M^2 assumed position A^1. During the first half of the throw to A, the angular speed being constant, A^2, A^3, A^4, etc.,

being equal arcs of the circle, it will be easily seen that the lateral distances corresponding to A^2, A^3, A^4, etc., on line D-C are constantly increasing. In other words as the quadrant approaches the perpendicular, the amount of chain from the drum is constantly decreasing for corresponding arcs, the direction of the quadrant more nearly approaching that of the carriage.

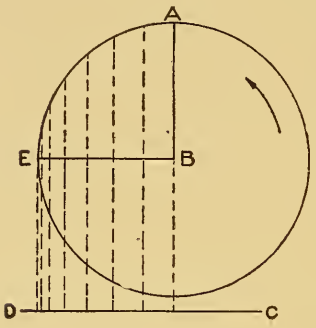


Fig. 165.

As the quadrant turns forward, the speed of the spindles is reversed, constantly increasing as the carriage moves in. Fig. 165 illustrates this point. Fig. 166 shows the actual throw of the quadrant.

The speed of the spindles while running in is also varied by the speed of the carriage, which starts in slowly, increasing and then decreasing its speed till it strikes in.

Counter Faller. The counter faller takes care of the slack yarn and its position indicates whether the spindles are making the correct number of revolutions. If the counter faller is too high it shows that there is too much slack yarn, and to overcome this, the quadrant is wound down a little, thereby increasing the number of revolutions of the spindles. If the faller is too low the quadrant should be wound up, otherwise the yarn may be strained or broken. The tension faller should be a trifle above the top of the bobbin just before the carriage strikes in and the fallers change.

The quadrant chain is rewound on the drum in the following manner: Referring to Fig. 162 it will be seen that a rope M^7 is fast to and wound around the drum M^4 in a direction opposite to that of the quadrant chain. The unwinding of the quadrant chain winds up the rope M^7, which passes under a pulley fast to the floor and then over another pulley on the head. It also has a heavy weight attached. When the carriage strikes in, the clutches M^9 and M^{10} are thrown out of contact, and as the carriage runs out the rope is unwound, thereby winding up the chain. The clutch is free at all times except during the running in of the carriage. This being the case the weight keeps the chain wound up at all times excepting when the chain is being unwound.

Building Device. The method of winding the yarn on the bobbins having been explained, the next thing to be considered is the device for controlling the size and shape of the bobbin. This consists primarily of a rail resting on shoes which control its height. Along the top of this rail runs the faller leg E^7, Fig. 167, which is attached to the faller rods by the casting E^6, consequently any motion imparted to E^7 will be transmitted to the faller E^4. An upward movement to the faller leg produces an opposite movement to the faller.

Builder Rail. When starting an empty set of bobbins the rail should be at its highest point (See Fig. 168, which is an enlarged view of Fig. 167), thus forcing the fallers to their lowest point; *i. e.*, the bottom of the bobbin. When the backing off is completed, Q^2 is in some such position as A and the winding faller is at the top of the cone. As the carriage runs in, the pulley Q^2 runs up the short incline Q^1, forcing the faller quickly to the bottom of the cone, thus winding the yarn down to this point in coarse spirals.

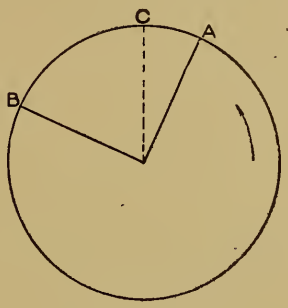


Fig. 166.

From the highest point of the short incline to the end of the builder rail, the fall is gradual, thus causing the fallers to rise slowly, and the yarn to be wound in close spirals to the top of the cone. This method of winding the yarn in coarse and fine spirals produces a very firm bobbin. Just before the carriage gets clear in, the extended portion of the faller leg E^7 comes in contact with a casting Q^{24}, fastened to the floor, causing the leg to slip off the point Q^4, thus allowing the leg to drop, and forcing the fallers to their original position. When the mule backs-off, the leg again slides back over Q^4, due to the fact that chain Z^4 is wound down, and acting on casting Z^5, turns shaft E^2 part way over and lifts the leg which is attached.

The method of lowering the rail so as to cause the fallers to gradually rise in order to form the bobbin is as follows: The two parts of the rail are controlled by separate shoes or inclines Q^5, Q^6, Q^7, which in turn are controlled by one screw. As previously stated the bobbins are started with the rail at the highest point of the shoes,

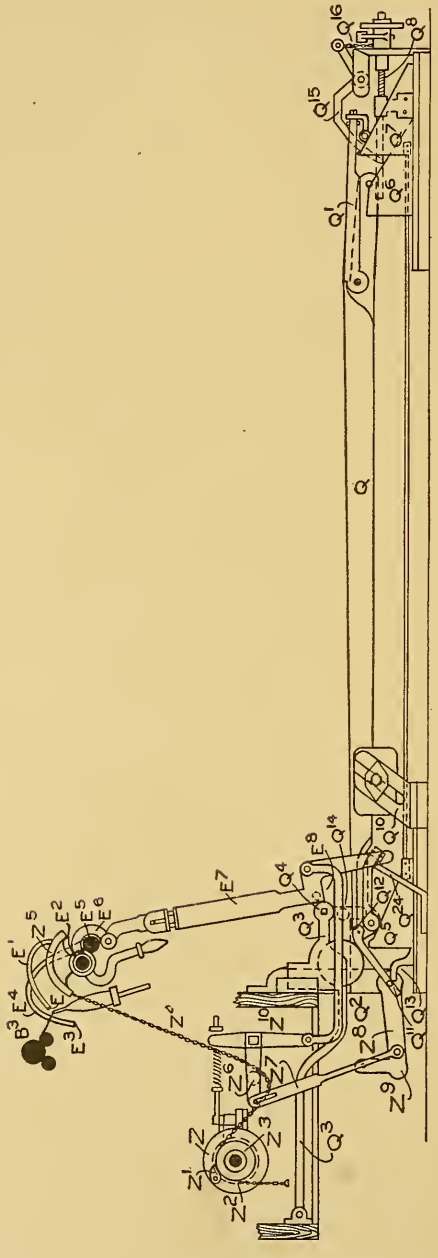


Fig. 167.

and in order to cause it to drop the shoes must move in toward the head of the mule.

The shoes Q^6 and Q^7 are fastened together while Q^6 and Q^5 are connected by the rod Q^9. The rail Q is kept in contact with the shoes Q^7 by means of a dog which slides in the slot in the casting Q^{10} as the rail drops. The small part of the rail Q^1 is controlled by a separate shoe Q^7. As the shoes move in the ends of the rail drop faster than the middle, till the base of the bobbin has been formed and the shoe will have moved so that the rail rests at the point A', Fig. 168.

As the rail descends, the incline Q^1 becomes steeper, thus forcing the faller to rise a greater distance at each stretch, till the base of the bobbin has been formed. As the rail descends, it is thrust forward, due to the fact that the dog drops in the casting Q^{10} at an angle. The effect of this is to lengthen the incline Q^1, which controls the winding

faller as it descends from the top to the bottom of the cone, consequently the longer the time it takes to go from the starting point A to the top of the rail, the more turns the spindle will have made and the greater number of spirals will have been wound on the bobbin, making it much firmer.

The moving of shoe Q^5 forces the casting Q^{13} against the incline Q^{11}, gradually raising it. As Q^2 runs down the rail this constantly changing angle in the rail causes a slight increase in tension at this point, thus winding the yarn harder and making the nose of the bobbin firmer.

The method employed to move the shoes is as follows: Referring to Fig. 167, it will be seen that the roll Q^{14} is in such a position that

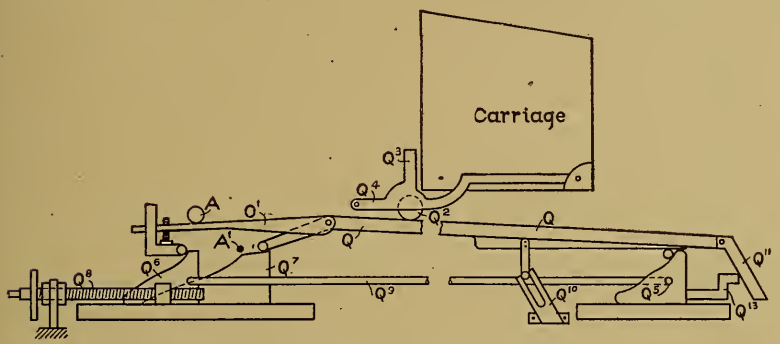


Fig. 168. Details of Builder Shoe and Rail.

as the carriage runs out it will come in contact with lever Q^{15}, causing the sickle-shaped pair to drop, thus raising the other end and chain attached to it, which in turn raises the lever arm Q^{17}. (Fig.169.) This lever is pivoted, one end supporting a pawl which meshes with a ratchet fastened to the other end.

Fast to the ratchet is a gear Q^{20} which meshes with the gear Q^{21}. The latter is fast to the screw Q^8, which moves the builder shoes. When the roll Q^{14} forces down the lever Q^{15} it lifts the ratchet Q^{19} and the gear Q^{21}, causing the gear Q^{21} to turn as the pawl locks with the ratchet, when it is moved in this direction. As soon as roll Q^{14} leaves the lever, the ratchet and gear drop to their former position, leaving gear Q^{21} at the point to which it was turned. The pawl disengages itself when the ratchet is turned in this direction.

The rapidity with which the screw Q^8 is turned depends upon the

position of the plate Q^{22} which stops the ratchet and gear when they drop. The higher the plate, the less distance the large gear will be moved at each draw of the carriage, consequently the slower the rail will drop and the larger bobbin will be formed.

The position of Q^{14} also controls the fall of the rail, for the lower the roll the higher the ratchet will be raised, and the faster the screw will be turned. Also, if the roll is so placed that it will run over the lever, and force it down again as the carriage runs in, the rail will be dropped twice as fast as if the roll moved the lever only once. A bobbin built by the roller striking the lever only once would be twice the size of a bobbin built when the roll forced the lever down twice at each stretch.

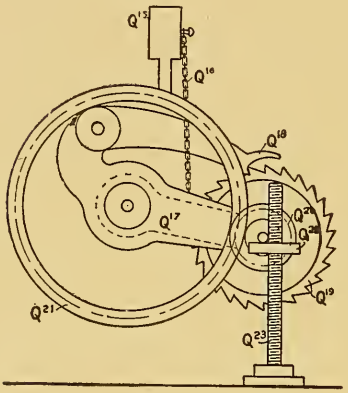


Fig. 169.

Twist Slide. In previous remarks considerable has been said about twist, and we will now consider one of the most important parts of the mule, known as the twist slide.

When the mule is started a triangular-shaped piece of metal (P^1, Fig. 170) connected by a rod to the starting lever, is moved so that it allows the spring P^3 to act on the lever arm and force the belt on F^3 (Fig. 156) or drawing-out pulley. The shipper is kept in this position by the spring P^3 holding it against the projection P^5.

A safety device known as a *detent lever* prevents the belt being shipped to the third pulley and the consequent starting out of the carriage unless a casting on the back of the carriage has forced in the detent lever P^7, allowing the catch P^6 to hold it. This casting is controlled by a rod on the front of the carriage. This clears the way so that the spring P^3 can act on the belt shipper, throwing the belt on the third pulley.

The dropping of the twist frees the lever from the catch and unless the casting on the carriage replaces it at every draw, the carriage will stop, due to the fact that the belt is kept on the loose pulley. The shipping of the belt to the third pulley causes the main shaft to

revolve as the pulley is attached to it, thus causing the bevel gear F^9 (also shown in Fig. 156) to revolve. F^9 meshes with a bevel gear on a short shaft at right angles to it.

On this shaft is a gear U, which is perforated with holes in such a manner that pins may be set in it. The turning of the main shaft causes the plate to revolve, forcing a finger against pins set in another

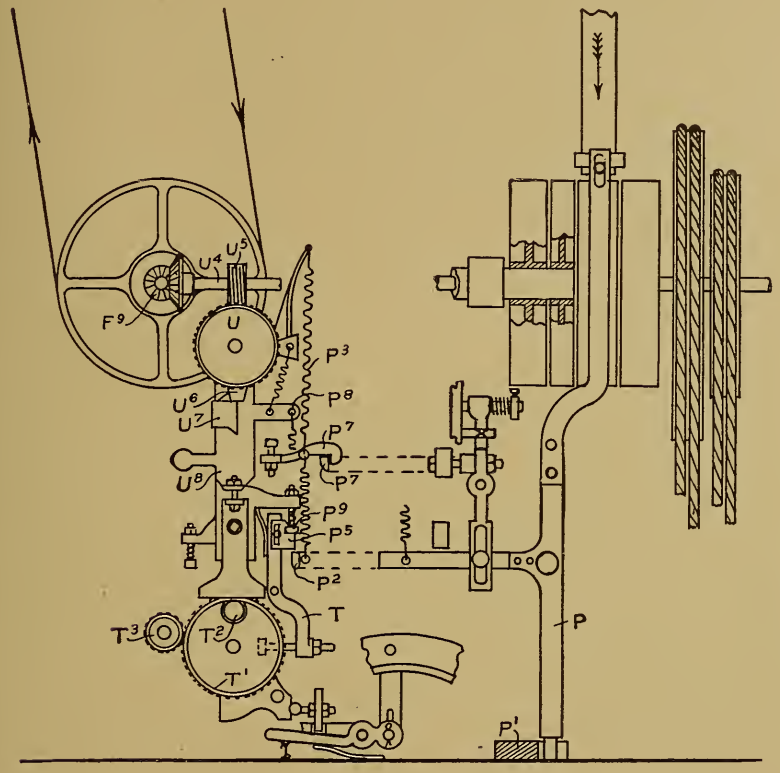


Fig. 170. Details of Twist Slide.

plate, thus forcing the casting U^6 to slip by casting U^7, this allowing gear and slide to drop.

The dropping of the twist liberates the detent lever so that the carriage will stop when it strikes in unless it is forced back under the catch P^6. The dropping of the twist also brings the bolt P^9 in contact with the projecting arm of the belt shipper, forcing the belt to the second or drawing-in pulley.

In addition to the above, the way is cleared so that the back-off friction may be thrown in. The twist slide is replaced by a roller fastened to the gear T^1, which is driven from the drawing-in shaft. The pins in the twist gear are adjusted to give the required twist. The dropping of the slide liberates the gear from the worm, and a weight which has been wound up, forces the gear to its former position.

So far the principal functions of the mule have been dealt with, and now a detailed account of the mechanisms which enable the various parts of the machine to perform their duties, will be taken up.

Operation. Starting with the carriage clear in, with the belt on the loose pulley F^1 (Fig. 156), the first thing to do is to move the rod, on the front of the carriage, which forces the detent lever P^7 (Fig. 170) under the clutch P^6, thus clearing the way for the belt shipper to move. Next the starting lever is moved, forcing the casting P^1 out of contact with P and allowing the spring P^3 to act on P, forcing the belt to the third or drawing-out pulley F^3 (Fig. 156). F^6, being fast to the shaft, drives down through the gears F^7, F^{10}, F^{11}, F^{12}, clutch F^{13} and F^{14}, causing the shaft F, to which the drawing-out scroll G^1 is attached, to revolve, winding up the rope G^2, thus winding out or drawing out the carriage.

Driven from F^{12} (Fig. 160) is the roving motion, which causes the drawing-off rolls and the drums, which are driven from them, to revolve, thus unwinding the roving from the spools. Driven from the gear F^{12}, by means of the gear R, bevel gears R^1 and R^2, and the shaft R^3, is a bevel gear R^4 which meshes with another bevel gear R^5 which is attached to one half of a clutch loose on the rear delivery roll. The other half of the clutch slides on a key in the shaft, and when the two clutches are in contact, the delivery rolls revolve.

The number of revolutions of the delivery rolls or the amount of roving given off is controlled by pins set in a gear which is so arranged that it may be thrown into or out of contact with a worm on the delivery roll. When the proper amount of roving has been given off the pins in the roving gear release a catch, allowing a spring to draw the gear out of contact with the worm and also forcing the two parts of the clutch out of contact. This immediately stops the delivery of the roving.

When the roving gear is released, a small weight that has been wound up during the delivery of roving, causes the gear to return to

its former position. The roving gear is put in contact with the worm by the carriage as it strikes in. During the outward run of the carriage, the spindles are turned by means of the rim band pulley F^6 which is fast to the shaft. As previously stated this band drives the drum C^4 (Fig. 158) from which the spindles receive their power.

Latch Rod. When the carriage reaches the end of the stretch the drawing-out clutch F^{14} is thrown out of gear and the easing up motion is thrown into gear. The carriage strikes the bunter S (Fig. 171) which, acting through the rod S^1, forces back the wedge S^{11}, which raises the dog S^2, connected to the latch rod S^3, from a slot in S^4. The raising of this dog S^2 allows a powerful spring S^6 to draw back the slide S^4. It will easily be seen from the shape of the casting S^4 (Fig. 172) that if it were drawn back, the end of the drawing-out clutch lever S^5 would be forced to slip into the hollow in the end of the casting, thus forcing the clutch out of gear, and stopping the carriage in its outward motion.

At this point the belt is shipped to the fourth or accelerated speed pulley F^4 by means of a roll on the back of the gear T^1 (Fig. 170), which acting on the lever T forces the catch P^5 out of position, allowing the spring P^3 to draw the lever against P^9, thus shipping the belt to the fourth pulley. The striking out of the carriage also forces the easing-up motion into gear.

In its normal position a projection on S^4 keeps the upper half of the easing-up clutch L^3 out of gear with L^4, but as soon as S^4 is forced back the clutch drops into gear, and as it is receiving power from the shaft L, draws in the carriage a certain amount, depending upon the twist. When sufficient twist has been put into the yarn, the twist slide drops, causing the belt to be shipped to the second or drawing-in pulley. This causes the rim band to be reversed, consequently reversing or backing-off the spindles and causing the fallers to change.

The falling of the twist as previously stated ships the belt to the second pulley and also releases the back-off lever so that the spring S^6 (Fig. 172) draws it back, forcing the back-off friction clutch into gear and thus driving the clutch in a direction opposite to that in which the rim band has been running.

With the shifting of the belt to the second pulley, the grooved pulley H^1 becomes the driver of the rim band, and as it runs in the

opposite direction to that in which the band has been running, the spindles are reversed, unwinding the yarn.

Fast to the drum shaft in the carriage is a ratchet Z^2 (Fig. 173) which on the outward run of the carriage turns free, but as soon as the drum is reversed, pawl Z^1, controlled by a spring engages with the ratchet and causes drum Y^3, to which it is attached, to revolve, winding up the faller chain Z^4. (Figs. 173 and 167.) The winding up of this chain draws down the segment Z^5 on the faller rods and raises the faller leg E^7 till it slips over the end of the casting Q^4, which travels on the top of the builder rail Q.

The lifting of the leg over Q causes a spring to pull Z^{10} and Z^{11}, forcing the cluch M^9 and M^{10} into gear. This clutch controls the

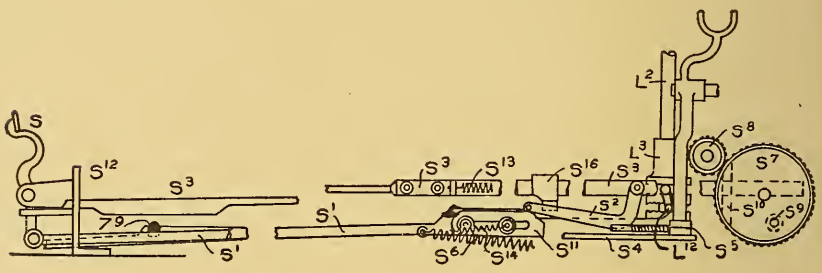
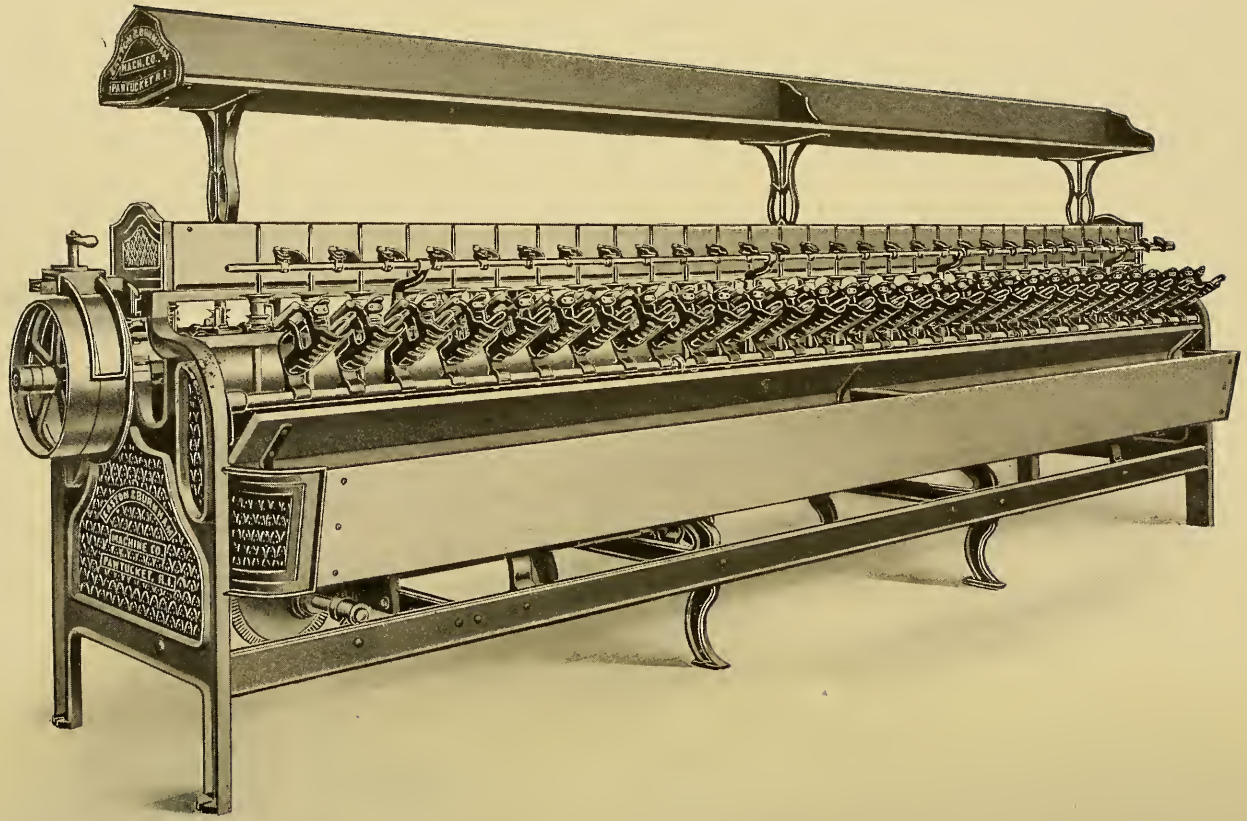


Fig. 171. Details of Latch Rod.

winding of the yarn on the bobbin, as it allows the quadrant chain to turn the spindles. (See Fig. 162.) As the faller chain Z^4 is wound down and faller leg E^7 is raised, roll Z^6 is lifted, raising Z^7 and Z^8, which are connected to it. Fast to Z^8 is a pin which rests in a slot in the easing-up rod L^7 (Fig. 160), which up to this time has been drawing in the carriage quite slowly as the twist is being put in, thus throwing the easing-up motion out of gear.

Simultaneous with the lifting of this pin the latch rod is lifted and drawn back by a spring, thus allowing the dog S^2 to drop back into place in the slide S^4, so that a roll on gear S^7, which is driven from the gear S^8 on the drawing-in shaft, may force the drawing-out slide and latch rod back into place. This allows the latch rod to catch on the casting S^{12}, holding both the slide and rod in position.

The drawing-in of the latch rod brings the casting S^{16} on the rod into contact with the lever S^{15}, which forces the backing-off friction out of contact and the drawing-in clutch into gear, causing the carriage



BOBBIN SPOOLER WITH EASTON & BURNHAM HOLDER

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to be drawn in. The drawing-in clutch is thrown out of gear by the carriage striking against the lever Y (Fig. 161), which releases the backing-off lever S^{15}, allowing the spring S^6 to draw it to a neutral position. During the running in of the carriage, the yarn is being wound on the bobbins, the action being controlled by the winding faller, which in turn is controlled by the builder rail through the medium of the faller leg. The above completes a full cycle of the motion of a mule.

Doffing. When the bobbins have been filled, it is necessary to remove them and place empty ones on the spindles. This operation is known as doffing, and is performed as follows: While the carriage

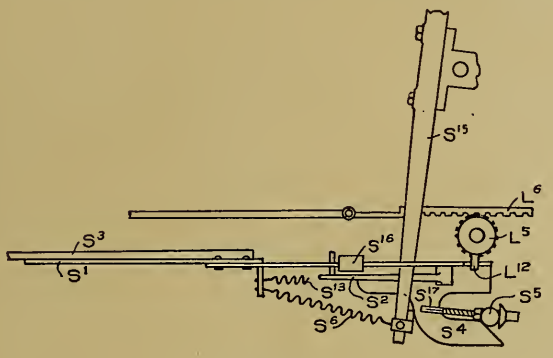


Fig. 172.

is coming out the builder rail is wound clear up, which causes the fallers to go to the bottom of the bobbin when the mule backs off. Stop the mule at this point; then move the carriage in a little, by means of the shipper handle, which causes the yarn to wind around the bottom of the bobbin. If the yarn is slack enough lock down the fallers and take a few turns of yarn on the spindle below the bobbin by pulling on the rim band. If the yarn is too tight to allow this, move in the carriage a little. Now take off the bobbins, replacing them with empty ones.

The quadrant chain is now wound down, the fallers unlocked, and a turn of yarn wound around the bobbins by pulling on the rim band. If the quadrant chain is not tight, pull the faller leg from its position on Q^4 which releases the winding clutch, allowing the weight attached to the drum to wind up the chain. Then press down the

fallers bringing the leg back into position, forcing the winding clutch into gear. The mule is now ready to start.

This is a description of only one of many methods employed in doffing a mule, the result being the same in all cases.

Different kinds of stock require different methods in spinning, and no hard or fast rule can be given as to draft, twist, etc. As a general thing short stock requires more twist than long stock, for in the latter the long fibers cannot draw by each other when twisted to any extent.

The longer the stock, the quicker the carriage must get away from the drawing-off rolls, because the twist *sets* much quicker than in short stock. The finer the stock, the slower the carriage must leave the rolls.

If the ends break about half-way between the carriage and rolls, the carriage is drawing too fast; while if the roving breaks near the

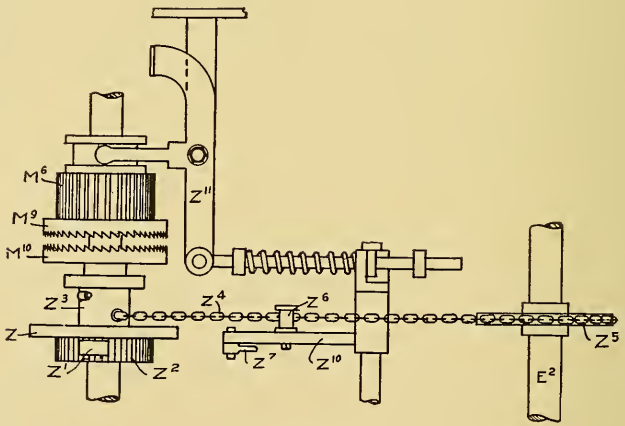


Fig. 173.

rolls it is taking the twist too fast, and the carriage must be drawn out quicker.

It is often found expedient to change the speed of the carriage to some extent, without changing the flanges or wings, to accommodate certain kinds of stock. This is done by turning the scroll G^1, Fig. 157, one way or the other, depending upon whether the yarn is taking the twist too quickly or not.

The greater the amount of drawing-out rope wound on the large diameter of the scroll, the greater the distance the carriage will travel

at high speed, and the less twist will be put into the roving before it commences to draw. This change in the position of the scroll is brought about by turning the drum G^5, Fig, 173, in the desired direction by means of the crank G^7 which meshes with the gear G^{11}, which is fast in the drum G^5. The drawing out rope G^2 passes around the pulley G^4 and is attached to one side of the drum G^5. The tension band G^3 is wound on the drum in the opposite direction. Turning the drum in either direction winds up the rope on one side and unwinds it on the other, thus causing the scroll to turn.

Mules are built in various sizes from 198 to 400 spindles and gauges from $1\frac{3}{4}$ to $2\frac{1}{2}$ inches. The machine described by the previous drawings and explanations is representative of the principles of mule spinning, being the Davis and Furber self-acting mule. The machines produced by various manufacturers differ some in the methods employed to bring about the various changes, but the results are the same.

TWISTING

In the doubling and twisting operation as in worsted spinning there are flyer, cap, and ring frames. The flyer frame is used very little; the ring frame being the best for general use, although the cap frame is preferable for fine yarns on account of the high speed at which it may be run. The cap frame is also used by some in preference to the ring frame on account of the expense of travelers on the latter.

A much larger bobbin can be used on the ring twister and the yarn can be wound tighter, therefore a greater length of yarn can be wound on the ring twister bobbin than can be wound on the cap twister bobbin. This is an important feature to the spooling room.

In spinning, the frames draw the yarn, twist it, and wind it on bobbins; in twisting, the frames simply twist the yarn and wind it on bobbins, the front rolls and spindles being the essential parts of the machine.

In order to avoid the large knots which would be caused by tying up the ends of the compound thread when one thread broke down, most twisting frames for doubling and twisting more than two threads are equipped with stop motions, which stop the delivery of yarn and allow the broken thread to be tied up before it passes through the

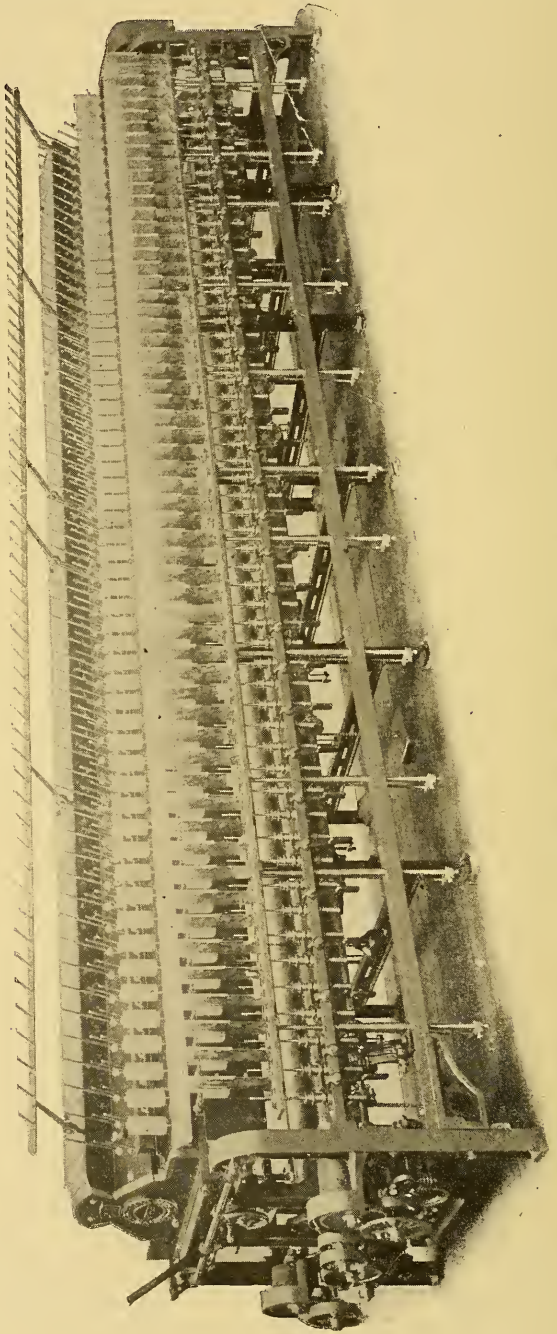


Fig. 174. Prince Smith Two-Ply Trap Twister.

front rolls. For fine two-ply yarns it makes little difference if both threads are tied up together, but in this case a stop motion saves a large amount of waste.

As there are so many makes of twisters, which differ only in the size and shape of rolls and in the method of driving, we will select representative machines for explanation.

Two-Ply Twister. The illustration Fig. 174 shows a Prince Smith two-ply trap twister. As will be seen there is an upright roll for each spindle. The bobbins of yarn to be twisted are placed in the creel. The ends are then passed through the small wire hooks or guides at the side of the rolls, wound once around the roll, passed down through the porcelain guide fixed to the lever or trap, and then through the traveler to the bobbin.

As long as both of the threads that are being twisted continue to run through the guide, the trap is held down and the roll is free to revolve, but if one thread breaks or one bobbin runs off before the other the twist in the remaining thread will be quickly taken out by the spindle which revolves in the opposite direction to the twist in the single yarn. This causes the single thread to break and allows the trap lever to rise.

The trap lever swings on a pivot, but the back part is a little heavier than the front which causes the back part to fall as soon as the action of the yarn, in passing from the upright roll to the traveler and spindle, is removed from the front part. The back part of the lever is provided with a catch which engages with the mechanism, which stops the roll and therefore stops the delivery of yarn.

Four-Ply Twister. The illustration, Fig. 175, shows a frame for twisting four threads together. Each thread passes through a stop motion detector before it reaches the front rolls. These detectors must necessarily be very light as the yarn must support their weight as it passes through them. When a thread breaks the detector, through which it passed, drops and engages with a rocking shaft. The rocking shaft knocks the upright bar, which supports the top roll, out of position and through its connections stops the spindle. In this manner the delivery of yarn is stopped and the spindle ceases to put in twist. It is very important that the spindle should stop promptly or extra twist will be put in the yarn that passes the front rolls before the delivery stops.

The value of devices for this purpose can be readily seen, for where three, four, or more threads are being twisted together the stop

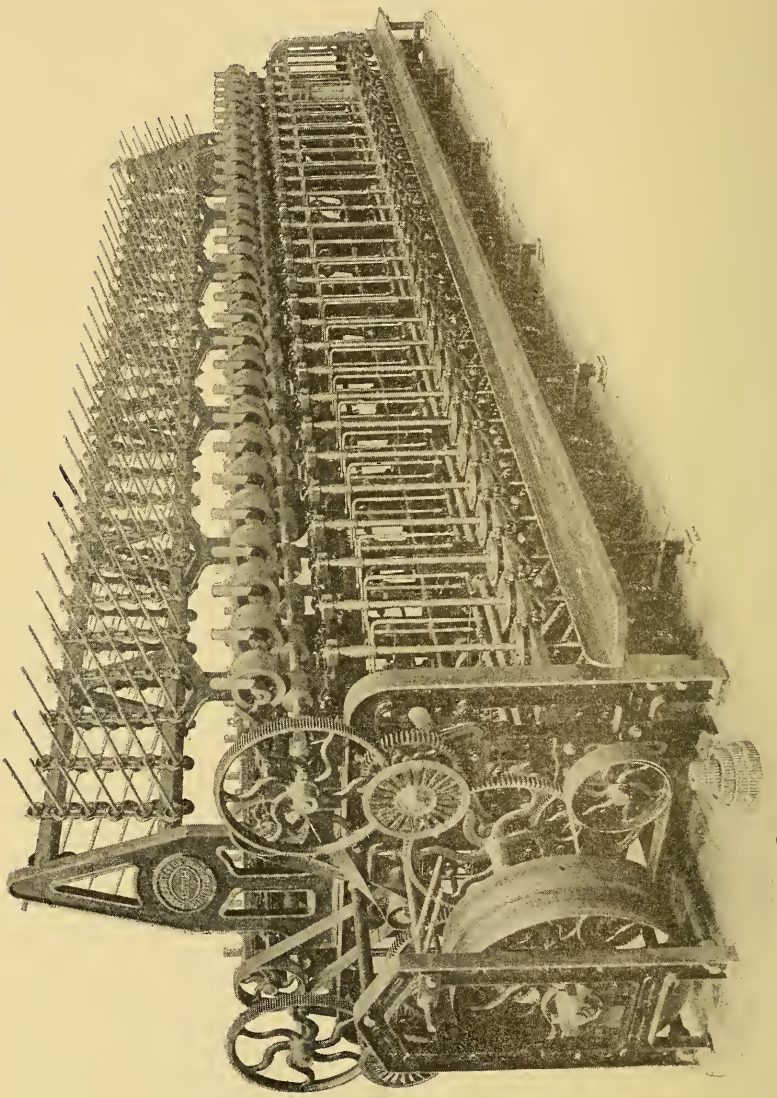


Fig. 175. Prince Smith Four-Ply Twister.

motion acts when one thread breaks or runs out, allowing the ends to be tied together without affecting the other threads. The small knot made in this way will scarcely be noticeable when twisted with

the other threads. These stop motions also effect a great saving in waste.

The method of calculating the number of turns of twist per inch is the same as in the spinning process. The number of turns of twist to put into yarn either in spinning or doubling and twisting varies so much for yarns that are to be used for various purposes that it is impossible to give a table of twists for every kind of yarn. The following tables, however, will give a good working idea of the twist required by representative yarns.

It must be remembered that in twisting two or more threads together the twist given on the twisting frame is in the opposite direction to that given the single yarn on the spinning frame. There are special cases where twisting is in the same direction as spinning, but this is done to produce a special effect.

TWO TO SIX-PLY YARNS

Crossbred Wools

Counts	Spinning	Twisting	Counts	Spinning	Twisting	Counts	Spinning	Twisting
2-1 1-4 Cord	4 1-2	4	2-24	8 1-2	7	4-8 Soft	3 1-2	2 1-4
2-2 "	5 1-2	4 1-2	2-26	9	7 1-2	4-8 Med.	4 1-2	3
2-3 "	6 1-2	5	3-8s Soft	4 1-2	2 9-10	4-9 Soft	4	2 1-2
2-4 "	7	5 1-2	3-9s "	4 6-10	3	4-9 Med.	5	3 1-2
2-5 "	7 1-2	6	3-10s " Very Soft	4 8-10	3 1-2	4-9 Hard	6 1-2	4
2-7 "	3	2 1-2	3-10 Soft	3 2-10	2 1-2	4-12 Soft	4 7-10	3 1-2
2-8 "	3 1-2	2 7-10	3-11 "	4	2 6-10	4-12 Med.	5 8-10	3 3-4
2-9 "	3 7-10	3	3-12 "	4	2 8-10	4-12 Hard	8	4 1-2
2-9 Hard	6 4-10	7 1-10	3-12 Hard	7 1-4	4 8-10	4-14 Soft	6	4
2-10 "	6 1-2	7 1-4	3-14 "	8	5 1-2	4-14 Hard	8	5
2-10 Soft	3 9-10	3 1-4	3-14 Soft	5	4	4-15 Soft	6	4
2-12 "	4 1-2	4	3-16 "	5 1-2	4 1-4	4-15 Hard	8 1-2	5 1-2
2-12 Hard	7	7 1-2	3-16 Hard	8 1-2	5 1-2	4-18 Soft	6 1-2	4 1-2
2-13 "	7 1-2	7 3-4	3-18 Soft	7	4	4-20 "	6 8-10	4 8-10
2-13 Med.	6	5 1-2	3-20 "	7 1-2	4 1-2	4-24 "	8 1-2	5
2-13 Soft	5	4 1-4	3-20 Hard	9	7 1-2	5-9s "	4 3-10	2 8-10
2-16	6 1-2	5	3-24 Soft	8 1-2	5	5-10s "	4 1-2	3
2-17	7 1-2	5 1-2	3-30 "	10	6	5-11s "	4 9-10	3 1-4
2-20	8	6	3-30 Hard	12	8	5-12s "	5 3-10	3 1-2

NOTE. In the above table the representative twists for a large variety of special yarns are given. In the column marked "Counts" the size of the finished or compound yarn is given. Under the heading "Spinning" the number of turns per inch of twist given the threads in the spinning operation, is shown. Under the heading "Twisting" the number of turns per inch of twist given in the doubling and twisting operation is shown.

The counts opposite the word "cord", in the first column, are for fancy cords to be used in upholstering, etc.

The terms "Hard" and "Soft" mean that those yarns, with the twists given, would be harder or softer, respectively, than usual. Yarns of this nature are sometimes required for special purposes.

WORSTED COATING YARNS

Australian Cross Bred for Worsted Coatings

WARP

Counts	Spinning	Twisting	Counts	Spinning	Twisting
2-26	10	9	2-32	12	11
2-28	10½	9½	2-36	13	12
2-30	11	10	2-40	14	14

½-BLOOD WOOLS

Counts	Spinning	Twisting	Counts	Spinning	Twisting
2-12	7	5	2-20	10	9½
2-14	8	6	2-24	11	10
2-16	8½	7	2-28	12	11
2-18	9	8	2-32	13	12

½-BLOOD WOOLS

Counts	Spinning	Twisting	Counts	Spinning	Twisting
2-18	9	8	2-30	12	10
2-20	10	8	2-36	13	12
2-26	11	9	2-40	14	14

½-BLOOD SLUB DYED

Counts	Spinning	Twisting	Counts	Spinning	Twisting
2-18	9	8	2-32	12	10
2-20	10	8	2-36	13	12
2-26	11	9	2-40	14	14

FILLING

Counts	Spinning	Twisting	Counts	Spinning	Twisting
2-26	10	6	2-32	12	6
2-28	10½	6	2-36	13	7
2-30	11	6	2-40	14	8

¼-BLOOD WOOLS

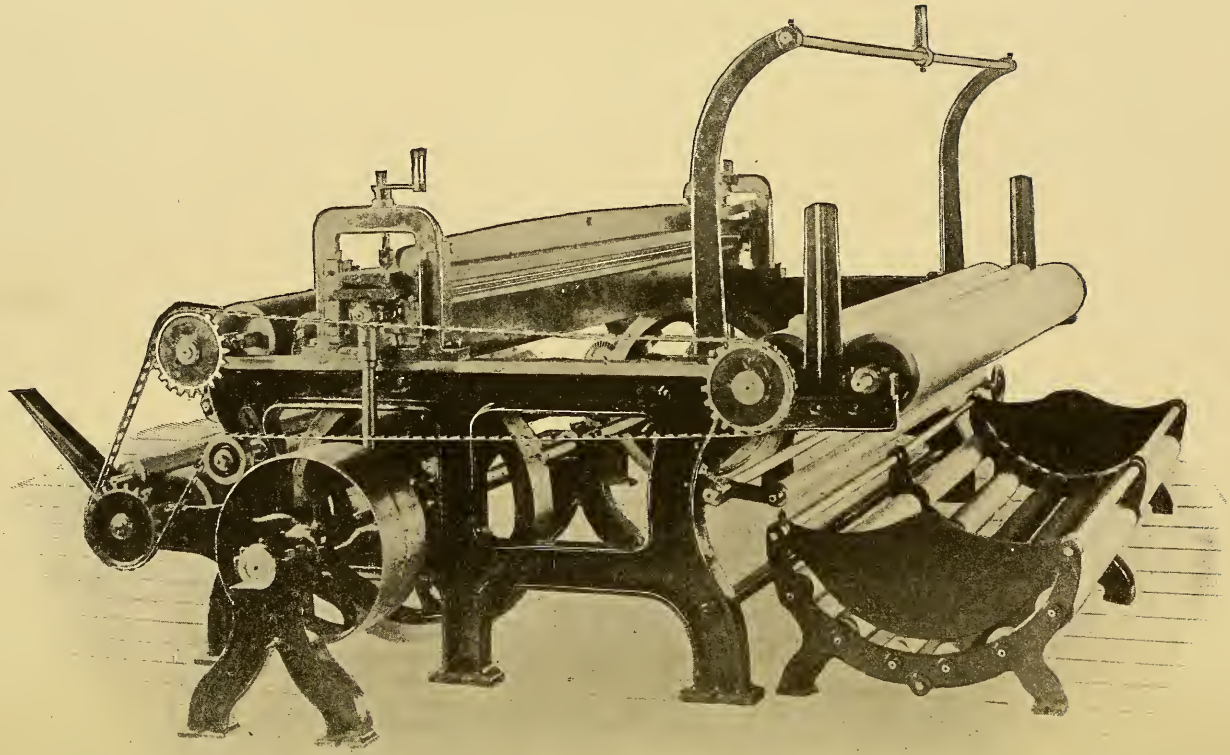
Counts	Spinning	Twisting	Counts	Spinning	Twisting
2-12	7	5	2-20	10	5
2-14	7½	5	2-24	11	5
2-16	8	5	2-28	12	6
2-18	9	5	2-32	13	7

½-BLOOD WOOLS

Counts	Spinning	Twisting	Counts	Spinning	Twisting
2-18	9	5	2-30	12	5
2-20	10	5	2-36	13	7
2-26	11	5	2-40	14	8

½-BLOOD SLUB DYED

Counts	Spinning	Twisting	Counts	Spinning	Twisting
2-18	9	7	2-32	12	8
2-20	10	7	2-36	13	8
2-26	11	7	2-40	14	8



NEEDLE PUNCHING MACHINE, BELT SIDE

Curtis & Marble Machine Co.

FELT

Judging by its appearance felt might readily be classed among woven goods; but this, it will be seen, would be a wrong classification, although it is termed cloth in many instances. Felt as such, however, displaces cloth to quite a large extent; for linings and trimmings it has become an indispensable article, which is largely due to its greater cheapness, and in the shoe and rubber trade large quantities are being consumed. The cheaper grades of gloves have felt for linings, and in the saddlery trade it is found to be not only a very useful but an almost indispensable material.

Stock. The stock from which felt is made varies, of course, with the quality and nature of the product to be made; but on the whole felt lends itself very readily to manipulation of the stock, and it is safe to say that there is very little waste made in the average woolen mill which cannot be used for some kind of felt. Long, coarse wool and the finest burr waste can be successfully used, and even cotton enters into quite a percentage of the products of felt mills.

The first and most important requirement for the superintendent of a felt mill is a thorough knowledge of the various kinds of stock, especially in regard to their felting properties; for while it is true that much stock can be and is used which does not possess felting properties, there must be some stock used which does possess these properties. Cotton is considered as being void of the felting capacity, but thousands of yards of linings and paddings are made every year from cotton.

Mixing. The mixing of the various grades of stock to be used for the required kind of felt is of the greatest importance, and therefore much care has to be exercised at this point, which is practically the first step in the process of felt manufacture. The stock to be mixed is thoroughly dusted and then taken to the mixing-room, where it is placed in even layers. A thin layer of the longest stapled stock is usually placed at the bottom, and the various other kinds are then placed on top of this in thin layers. The man in charge of the work

must see that the different qualities of stock used are also evenly distributed throughout the batch. For instance, if the batch to be made is 3000 pounds, and six grades of stock enter into it in the following proportion: 1000 pounds of one grade, 600 pounds of a second grade, 450 pounds of a third grade, 375 pounds of a fourth grade, 375 pounds of a fifth grade, and 200 pounds of a sixth grade, it can readily be seen that the various layers must be in proportion to the amount of each kind of stock.

It is usual to make from four to five layers of each kind of stock to be used, and the whole amount is then divided so that each layer of that kind will receive an equal amount. To illustrate this a little more clearly, let us follow the mixing process of the imaginary batch mentioned above.

Assume that each quality of stock is to be divided into five different layers, which gives thirty layers for the whole batch. This would give 200 pounds to a layer of the first kind, 120 pounds of the second, 90 pounds of the third, 75 pounds each of the fourth and fifth, and 40 pounds of the sixth. Now, it does not matter in which order the stock is put down, so long as the proper amount of each kind is taken and the same order is observed in all the layers.

The stock is then fed to the mixing-picker. This simple operation should be performed very carefully for felt. The stock must be taken from the batch with a vertical movement in order to produce a good mix, for, if this is not carefully observed, the poor stock will not be mixed with the better grade as thoroughly as it should be.

At this point a departure from the usual way of preparing batches will be noted, for no emulsion of oil is added to the stock, it being fed to the picker dry. While simple moisture is not harmful to the operations used in making felt, it would however upset calculations, for as such moisture would be an unknown and undeterminable quantity, it can be seen that no correct provision can be made for it. The case of oil, on the other hand, is quite different; for oil is positively a detriment to stock intended for felts. It is impossible to get stock on which oil has been used into the condition necessary for the felting process proper, for it must be remembered that felt is not woven, and therefore the stock has to be prepared by what is termed the hardening process, in order that it may be properly handled at the fulling or felting process. All the stock used for felt has to be closely watched for the presence of oil, although if only a small quan-

tity is slightly oily it may pass, if the larger amount is entirely free from oil.

All the waste coming from woolen mills should be carefully inspected, in order to be on the safe side. In many places all such stock is thoroughly washed before using it; but this is an added expense, and the price obtained for the goods does not admit of its being done in most instances.

After the stock has been run through the mixing-picker, it is usually run through a burr-picker; not because the burring operation is necessary on all kinds of stock, but as there usually is a great variety of different grades of stock, it frequently happens that a batch is somewhat burry, and it is well to be on the safe side. In many places the stock is run twice through the same picker.

Carding. The stock after this careful treatment is ready for the carding process. The carding is, next to the mixing proper, of the greatest importance, for in order to have an even piece of felt, the carding must be even. Even carding cannot be done with the several machines in poor condition, and especial care must be taken that both cylinder and workers are perfectly true and well set. It also is necessary that the clothing should be of the proper sharpness, and it should be prevented from becoming too full by stripping at regular intervals. When these things are attended to as they should be, the carding process will not cause much trouble. The stock, after coming from the picker room, is fed to the first breaker card. As in ordinary feeding, the stock should be fed as evenly as possible, and automatic feeds are generally used.

When the carded stock arrives at the doffer, instead of being twisted into roving, as is done where a thread is to be produced, it is deposited upon a drum, which, revolving at the back of the doffing cylinder, takes the stock along and winds it. When the lap on the drum is thick enough, it is torn off and laid aside in sheets to await the next step in the process. The speed of the drum exerts quite an influence upon the product, for, if it runs too fast, the stock is stretched too much, while if it runs too slowly, the stock will be lumpy.

On the lower grades of felt the second breaker card is dispensed with in most mills, although the product could be much improved by its use. However, this is a matter of judgment, and much of the better grade of goods is made without the use of the second breaker.

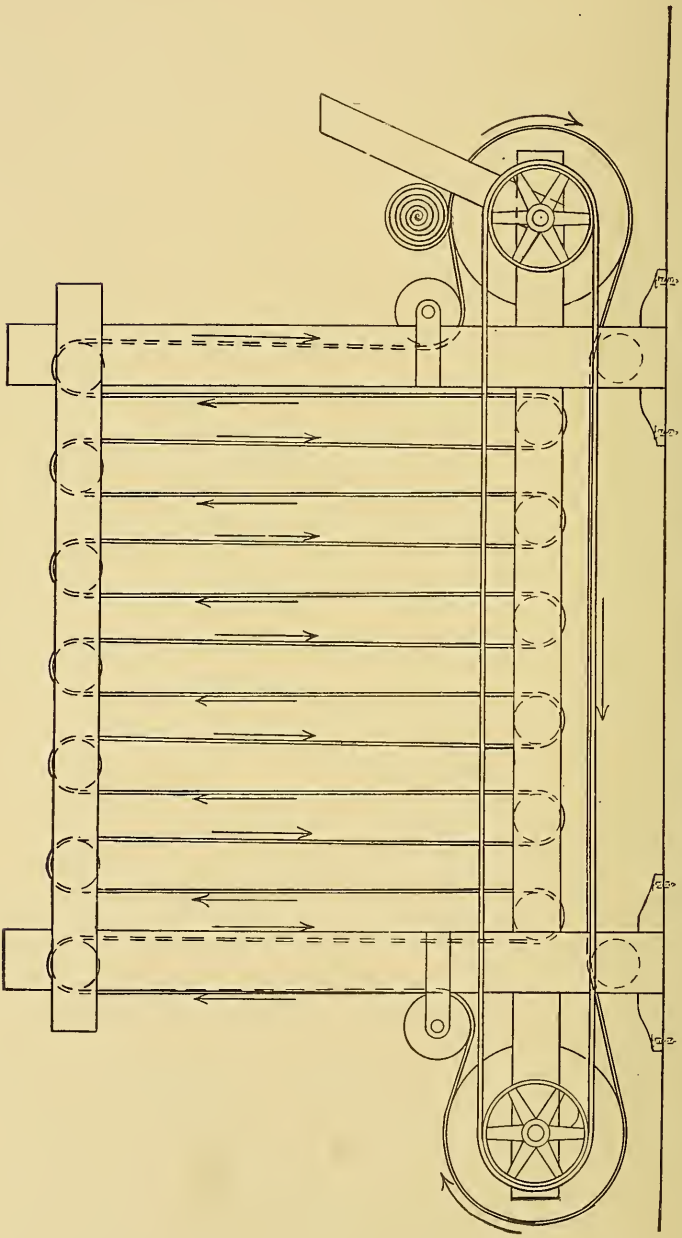


Fig. 1. Device Used for Winding up the Stock from the Former Card.

When the stock has been run through the breakers it is ready for the finisher card, which, in the language of the felting industry is termed the *"former"*. As the name implies, this card is used for the purpose of forming the carded stock into the proper shape for the piece of felt which is to be made, and for this reason the width of the machine has to be somewhat greater than the width of the goods, for the fulling, necessary to give the piece the required strength, cannot be performed without more or less shrinkage. Usually the former cards are from one hundred to one hundred six inches wide, and the feeding apron is supplied with guide boards, which can be set so that any width, within the limits of the machine, can be made. This card is provided also with a drum at the back under the doffer cylinder. The drum is used to operate an endless canvas apron, on which the stock is deposited.

At this stage a piece of felt is generally made forty yards long, therefore this is the length of the canvas apron. After passing around the drum, the apron passes over a series of rolls set in a frame, and as high as the room will allow. This is done for the purpose of economizing space. At the rear end of this stand of rolls another drum is placed, over which the apron also passes on its return journey. This drum is used to roll the stock on sticks when the carding process is completed. The diagram, Fig. 1, shows how the apron travels and also how the stock is wound upon the sticks.

When the guide boards have been properly set for the width wanted, the stock from the breaker card, which is lying ready in sheets, is carefully weighed and then fed evenly to the machine. The endless apron referred to above is connected with the machine, being virtually a part of it, so that when the machine is in motion, the apron also is in motion. When the stock comes from the doffer, it is deposited upon the apron and carried along with it, traveling around until all the stock required for the piece has been carded and deposited upon the apron. As soon as this is done, the stock is torn across on the drum at the rear and wound around a stick, commonly termed a batstick. This completes the carding process and the stock thus formed is termed a bat.

When the stock is ready to be made into bats and is weighed for the piece, allowance is made for the sides, which are generally thinner

than the body, and have to be trimmed off so that the goods may be of an even thickness.

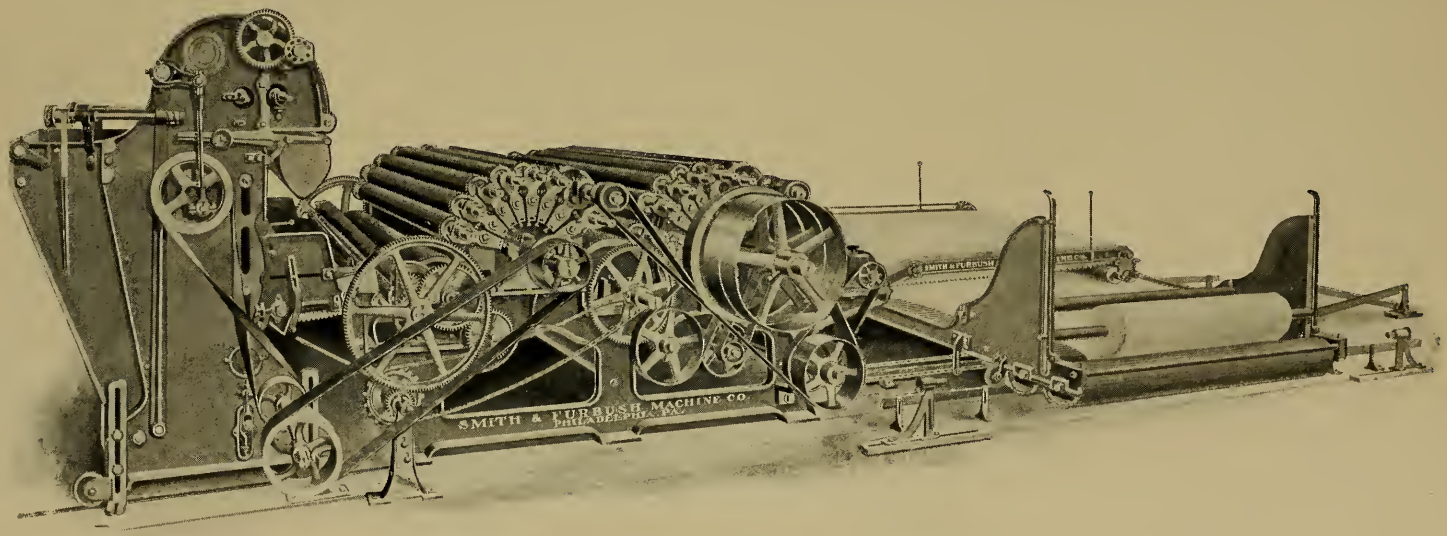
The method of procedure at this stage depends greatly upon the nature of the goods being made. On common weight goods the whole piece may be made in one bat, while on heavy goods two or more bats are sometimes made and placed together afterwards to get the required weight. All grades which are to weigh one pound to the yard, or less, are usually made in one bat; while those goods which are to weigh from two to ten or twelve pounds per yard are made in bats weighing from forty to sixty pounds, as the case may be.

When the bats have been made they are taken to the trimming table and are trimmed to width, and as many bats as are required for the piece are placed on top of each other. When trimmed the bats are again weighed, and they are then ready for the next step, which is termed *"hardening"*.

Hardening. When the stock has been carded into bats it is loose and can be handled only with greatest care. For this reason the hardening process is employed, to give the bat a consistency where it can be handled readily in subsequent processes. Hardening felt is a very simple process, but it requires quite a lot of time. The machine itself consists of a heavy iron framework supporting a strong cast-iron platen, which is thirty-two inches wide by one hundred ten inches long. A top platen of the same width, but two or three inches shorter, is over the first one, so that the actual width which the machine will handle is about one hundred six inches.

The accompanying illustration, Fig. 2, shows one style of hardener, and it will be observed that the machine is very solidly built. On the left side of the illustration the mechanism for its operation may be seen.

Hardening felt is an adaptation of the principles of fulling, which is employed here to give to felt its first stability. As is well known, the elements required for fulling are *pressure*, *moisture*, and *heat*, and all three are made use of at this process. The illustration gives only the mechanical part of the hardening operation, and the explanation is thus not complete. On each end of the hardener is placed a bench-like construction which corresponds with the bottom platen. On one end of the hardener this bench is about eight yards long, while on the other end it is about four yards long. Between the longer bench



BATTING MACHINE WITH AUTOMATIC FEED
Smith & Furbush Machine Co.

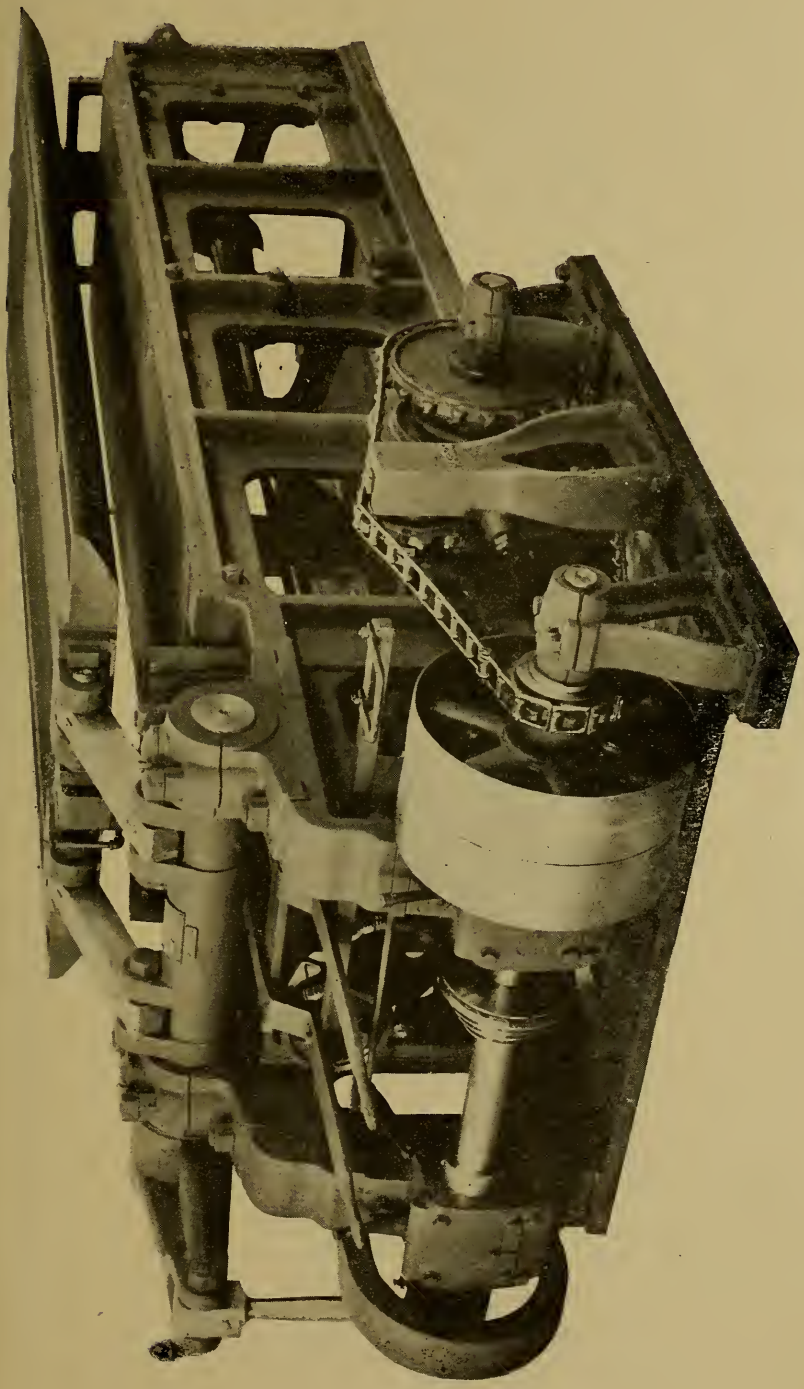


Fig. 2. Felt Hardener, for Fulling and Hardening Felt.

and the hardener is placed a steam box, which is covered with burlap to cause the steam to pass through evenly. At the outside of each platen a wooden frame, to which canvas is secured, is placed. The canvas is drawn tightly over both surfaces.

At the end of the benches is placed a shaft operated by a crank, and on this is wound another canvas apron from fifty to fifty-two yards long. The tops of the benches are covered with planks one foot wide, and there is a space between each plank to admit of a roll being placed between them. The canvas apron is first rolled up smoothly on the end of the eight yard bench, and the end is then drawn over the bench and steam box and passed between the platens. It is then brought to the shaft at the end of the other bench and secured. It will be seen that the rolls make it much easier to draw the apron along.

The bat, ready for hardening, is then placed upon this apron over the steam box, with the end just touching the edge of the bottom platen, and is unrolled toward the end of the bench. Care must be taken that no wrinkles are in either the apron or the bat. On top of the bat is placed an apron of burlap which has previously been smoothly rolled on a bat stick and this also is unrolled towards the end of the bench, thus covering the stock completely. After moistening this burlap apron, another bat is placed on top of it in the same manner as the first, and also another apron. This is continued until there are as many pieces as it is intended to treat.

The steam is then turned on in the steam box and the pieces saturated, after which the whole is drawn along by means of the shaft and crank at the end of the short bench, until the steamed part of the goods is between the platens. The top platen is then let down on the goods and the machine started. Now it will be seen by a glance at the illustration that a mechanism is provided to impart a reciprocating motion to the top platen. We have now the three elements of fulling in action; the steam supplying moisture and heat, and the top platen supplying the pressure.

The duration of the vibration is automatically controlled by means of a mechanism with gears and a wormshaft. When this mechanism has been set it will shift the belt from the tight to the loose pulley, thus stopping the vibration, and it will also lift the top platen. The steaming process of the next width has been going on during this time, and by drawing the apron ahead thirty-two inches, another

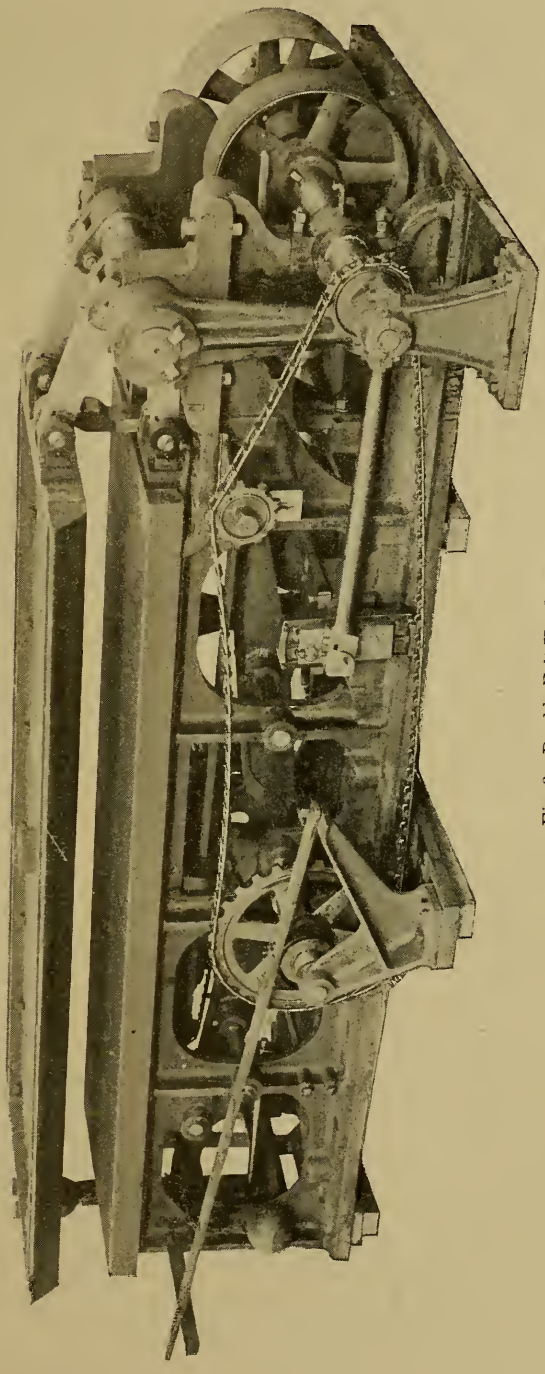


Fig. 3. Double Felt Hardener.

width is placed between the platens. The machine is again started, this being repeated until the end is reached. Both the bats and the burlap aprons are again rolled up on bat sticks, after passing through the hardener. The vibrations of the top platen referred to are very short, not exceeding one-half inch from one extreme to the other.

In Fig. 3 is shown another style of hardener, which is often termed a *double hardener,* because the machine is constructed in such a manner that the vibrations are imparted to both top and bottom platens. The vibratory motion thus being doubled, the machine will produce the same results as the single hardener in one-half the time. In all other respects the machines are alike.

Four pieces are usually treated at the hardener at one time by placing one bat on top of another as described, but this depends entirely upon the weight of the goods. For instance, on glove linings which weigh from ten to twelve ounces per yard, six pieces is the common practice; while on heavy laundry and saddlery felts, which weigh from ten to twelve pounds to the yard, one piece is all that can be treated at a time, and even then it is necessary to repeat the operation.

On some of the light weight goods also, it is often necessary to give two hardenings in order that they may be better handled at the fulling process. This is done as follows: To commence, three pieces are hardened, then placed on top of three fresh pieces and passed through the machine again. The first three pieces are then taken off the machine, and three more fresh pieces put through under the second three; and so on.

After the hardening process is completed the pieces are taken to the fulling room, unrolled, and drawn over a perch for examination. Every imperfection in carding will show, and the attention of the carders must be called to any unevenness in order that it may be remedied. After a careful examination the goods are ready for soaping, preparatory to putting them into the fulling machine..

The soaping operation is preferably performed with a machine similar to the one shown in Fig. 4. It is a very simple contrivance, consisting of two squeeze rolls marked A, the lower one of which is set in the tank C which contains the soap. On each side are guide rolls, a single one marked B on the side where the goods enter; and a set of two rolls also marked B on the other side, to take care of the goods

as they leave the squeeze rolls. The machine is made wide enough to admit of the pieces passing through open width, which is preferable to having them in the rope shape, common to ordinary soaping machines.

The soap used on felts is generally used very warm, as it is thus possible to use a better bodied soap, and also to provide the heat necessary in the fulling process. The strength of the soap need not

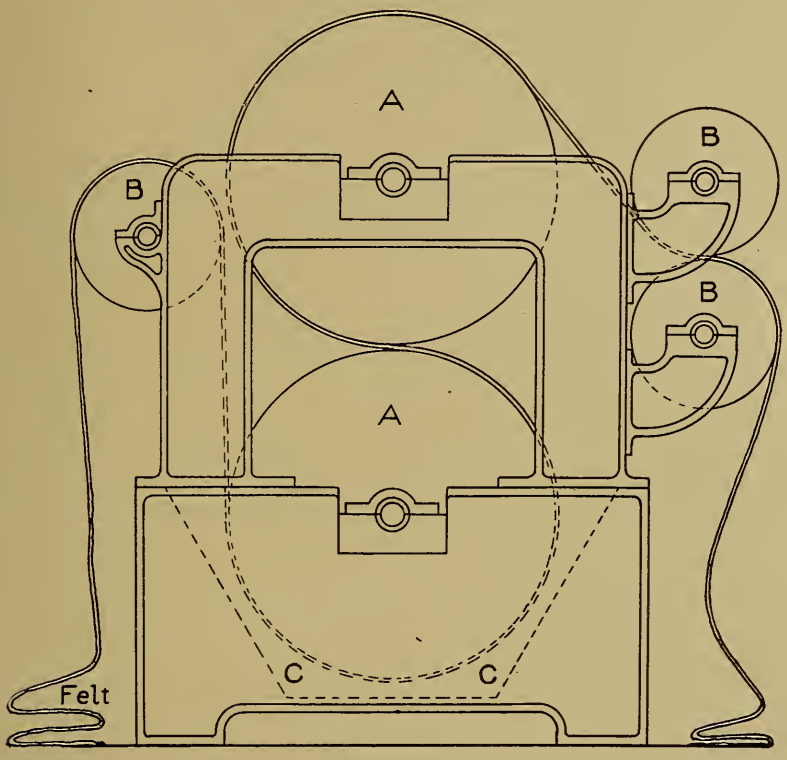


Fig. 4. Elevation of Soaping Machine.

be very great as there is not much, if any, oil or grease to loosen, but on account of alkali being a powerful aid in fulling, quite an amount may be used. These things do not go by rule, being subject to the judgment of the one who has charge of the fulling. In some instances it is found profitable to have the soap as near neutral as possible, and then add alkali, dissolved in hot water, near the end of the process.

Fulling. The machines used for fulling are of the old-fashioned kind, that is, the crank type of mill, for it is impossible to use rotary

mills on felts. There are two reasons why rotary mills are not adapted for this work: *first*, because the goods are not solid enough to stand the strain, and consequently would pull apart; and *second*, because the pieces, being in rope form, would felt together in that shape. As there are no provisions, on this style of fulling mill, to regulate the shrinkage in width and length, the desired end must be attained in another way.

The illustration, Fig. 5, shows a crank type fulling mill, and it will be seen that one or more pieces can be placed at either end. The sides are on hinges and can be let down to make it easier to remove the goods. The letters A, A, A, A, indicate the four sides of the mill which are made of 4-inch yellow pine. The top frame B, B, B, B, supports the shaft E to which the hammers C, C, are connected at D, D. The levers H connect the hammers to the crank shaft F which is driven by a belt on the pulley G. When the shaft revolves a reciprocating motion is imparted to the hammers.

When it is desired to full the goods up in length, they are placed in the machine so that the pressure exerted by the crank will be lengthwise, therefore the pieces are folded into the machine at full width. If, however, they are to be shrunk in width, they are placed in the machine from the side. When goods shrink in length, they should shrink more or less in width also; therefore it requires close attention on the part of the fuller to bring them out right.

After the goods have been placed in the machine and have run about ten minutes, or sometimes less, they must be carefully examined to see if they felt together. If there is any indication of felting, they must be taken out at once, and all wrinkles which have begun to felt together must be carefully pulled apart. The edges are generally the worst for this fault, and often cause much trouble and hard work to keep them smooth and open. The better the quality of the stock used the more trouble of this kind will be present, and it often requires from four to six men to operate one of these machines. It is not uncommon to find from thirty to forty men working in a fulling room with five or six fulling machines.

As the fulling operation nears completion, greater attention is required, for the goods should be taken from the machine and opened out more often. They are also carefully measured, both as to width and length, and if the width comes up faster than it should, the goods

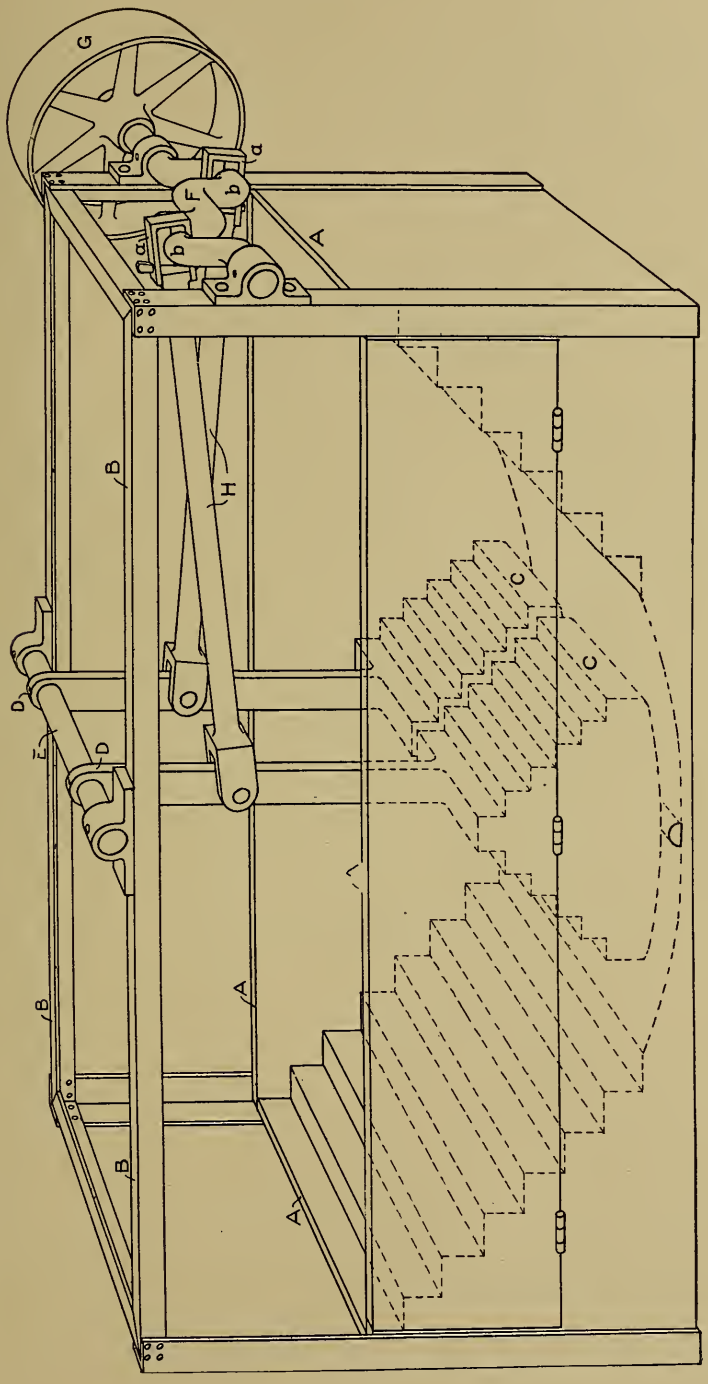


Fig. 5. Crank Type Fulling Mill for Fulling Felts.

have to be pulled apart again. This makes the work of the fulling room very hard, but there is no other way to get the desired results. There are goods which require additional alkali to hasten the fulling, but the same precautions as to taking them from the machine and opening out must be observed. When the pieces are finally taken from the machine and have been opened and measured and found right, they are ready for the washer.

Washing. The washing machines do not differ from ordinary washers, except that more room is given the goods. In a common eight-string washer only four pieces are treated at a time. This makes it possible to have the guide rings and throat plates, through which the goods have to pass, much larger than on woven goods.

After the goods are run into the washer and the ends sewed together, they are given a generous supply of warm water and run about fifteen minutes, after which the gates are opened and the lather rinsed off with warm water, followed by cold water. If the goods are to be fancy colors, they must be rinsed very thoroughly in order to remove all the soap, while if they are gray or white, a common washing and rinsing will answer. In washing felts it is often much the same as on woven goods, for some finishers think that goods cannot be washed clean unless soap is added in the washer. While there may be rare cases where it is advisable to use additional soap at the washing process, such cases are rare, and as a general rule it may be accepted as a foolish waste of good material. In addition to this, it will make the washing process slower, for the more soap in the goods, the longer time is required to remove it.

From the washer the goods are sent either to the dye house or to the extractor to be extracted before drying, according to the nature of the goods.

Drying. The drying process is the most particular operation in finishing felt goods, for the defects in other operations must be corrected. With even the greatest care in fulling, the pieces will not shrink evenly, some being long and narrow and others being shrunk too much in length and not enough in width. It is known how much stock there is in the piece, for in this respect all pieces of one style are supposed to weigh alike; the loss sustained in the various processes is also known; so that if the goods are to weigh a certain amount per yard when finished, it is an easy matter to figure how many yards

long the piece ought to be when finished. Therefore every piece that comes to the dryer is measured, and if it is short of the required length, it must be stretched in length sufficiently so that the piece will be right when it is dry.

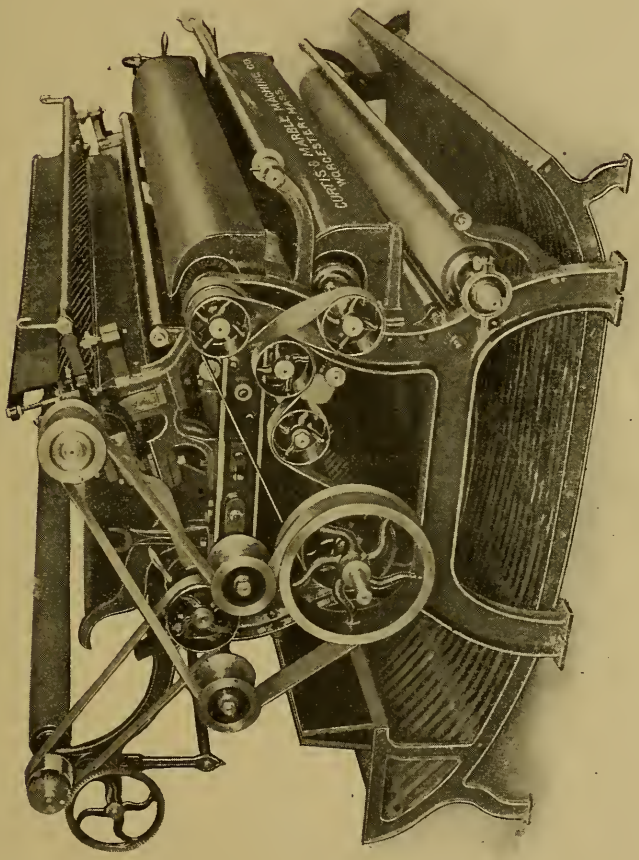


Fig. 6. Curtis & Marble Felt Shearing Machine.

So it will be seen that aside from the actual work of drying the pieces, much judgment is required to have uniform and satisfactory work result.

After-processes vary with the quality of the goods. A common padding or white cotton glove lining is usually passed through the

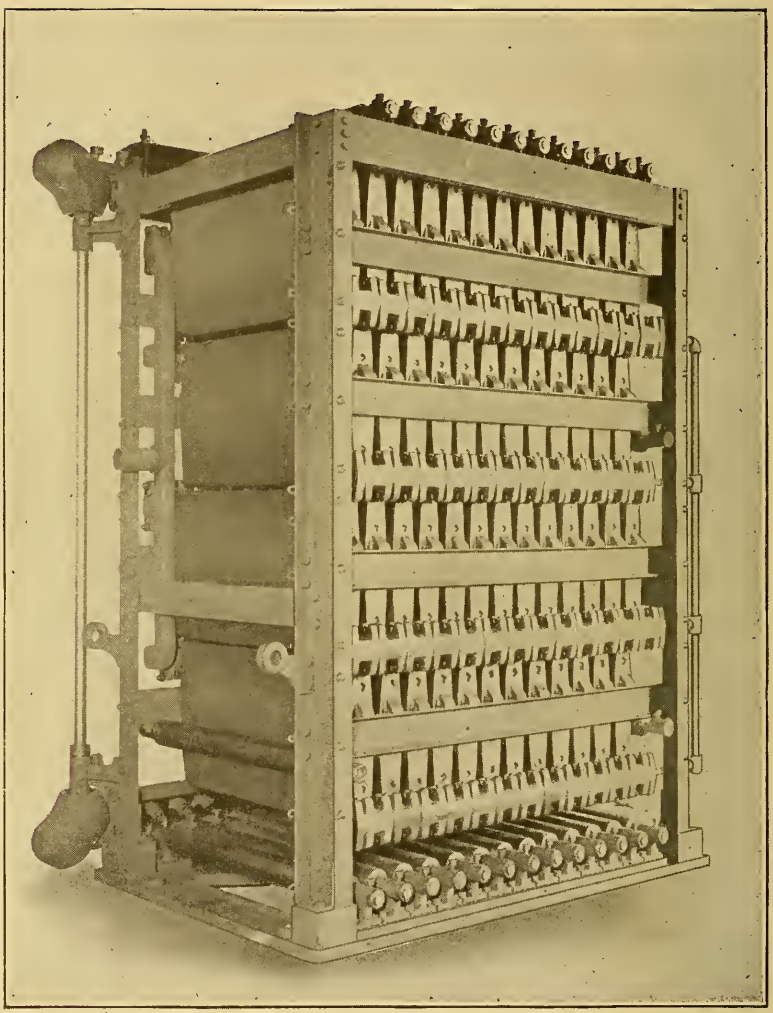
press and then rolled up, measured, *etc.* These goods are given a bath of starch after the washing is completed, which makes them feel more substantial than they really are. In the case of all cotton linings this starch bath is a necessity, for without it, it would be difficult to get the desired article. Such goods as these require very little labor in the finishing room, but hat felts cause much more work.

There are two kinds of hat felt, the *smooth* and the *rough*. The smooth hat felt is taken from the washer to the extractor and partly extracted, that is, more moisture is left in the goods than would be done if they were intended to be dried. From the extractor the pieces are taken to the napper and both sides thoroughly napped. They are then sent to the dye house to be colored. When they return, they are thoroughly extracted and dried, after which they are again taken to the napper and receive one run on each side. The sandpapering machine follows, each side being given one or more runs to smooth the face, and the goods are ready for shearing. Fig. 6 shows a felt shearing machine. The goods are sheared down so that the face as well as the back will be perfectly smooth, after which they pass to be pressed and the usual final work.

On rough hat felts, as a rule, the wet napping is omitted and they are napped after coming from the dryer. This class of felt requires the use of mohair, and as this is an expensive article, it is customary to have the middle of good filling stock and a layer of mohair on each side. After the fulling the mohair is held tightly by the body felt, for it has very little of the felting property itself. This fact must be remembered when the goods are napped, or the nap will be thin and straggling.

For the purpose of napping the ordinary mohair hat felt, a machine resembling a double cylinder brushing machine is used, only the brushes are lacking and the cylinders are covered with fancy card clothing. On low grade mohair hat felts the rear cylinder is often replaced by a brush cylinder, thus leaving only one napping cylinder. Most mohair hat felts are measured and rolled up immediately after napping, but on the finer grades, where it is an object to bring out the luster of the mohair, the wet napping process is employed, and after drying they are again lightly napped and sent to the press for a good hard pressing.

Shoe felts are usually of low grade but are felted as solid as possi-



FIFTY CELL DRYER, WITH HOUSING REMOVED, FOR DRYING CLOTH
Vacuum Process Co.

ble. These pass from the washer to the dye house to be colored, usually black. They are then dried and thoroughly sandpapered. Shearing follows, for they also have to be as smooth as possible. They are then pressed hard, and are ready for the final work of measuring, *etc.*

The machines used for sandpapering are usually the nappers referred to, but the card clothing is taken off and the cylinders covered with sandpaper. The processes in the finishing room do not differ materially from those employed in other mills, for the goods are in most respects treated like cloth. Some difference is noted when handling heavy laundry felts, for such goods cannot be handled in lengths over ten yards; neither can they be doubled, therefore they are rolled up full width and sent to the market. After the drying process is completed they are at once measured and packed.

Felts are made for almost every imaginable purpose, but in the foregoing the chief points in handling felt have been given, and on the whole there is very little departure from the methods explained.

PUNCHED OR NEEDLE FELT

Another class of felt merits mention; namely, the so-called *Punched* or *Needle Felt.* It is chiefly used for the cheaper grades of stable blankets, and has excellent wearing qualities.

The stock used for this class of goods must be of good felting quality and should not be of too long staple. It is not desired to have much nap on the blankets, for the more nap there is on them, the sooner the wool stock will wear off, but if a good felting short-stapled stock is used, and if the pieces have been well felted in the fulling process, a good serviceable article will be the result.

The carding process is practically the same as before described, and as soon as the stock has been properly rolled on the bat stick it is taken to the punching machine, an illustration of which is shown in Fig. 7.

The body of the goods consists of a good quality burlap, and the wool stock is deposited on each side of this, so that when done, the burlap is entirely hidden from sight. The punching machine is used to make the wool adhere to the burlap until it is properly felted. It will be seen that the mechanism is extremely simple, consisting chiefly of a series of rolls for moving the burlap and stock, and the

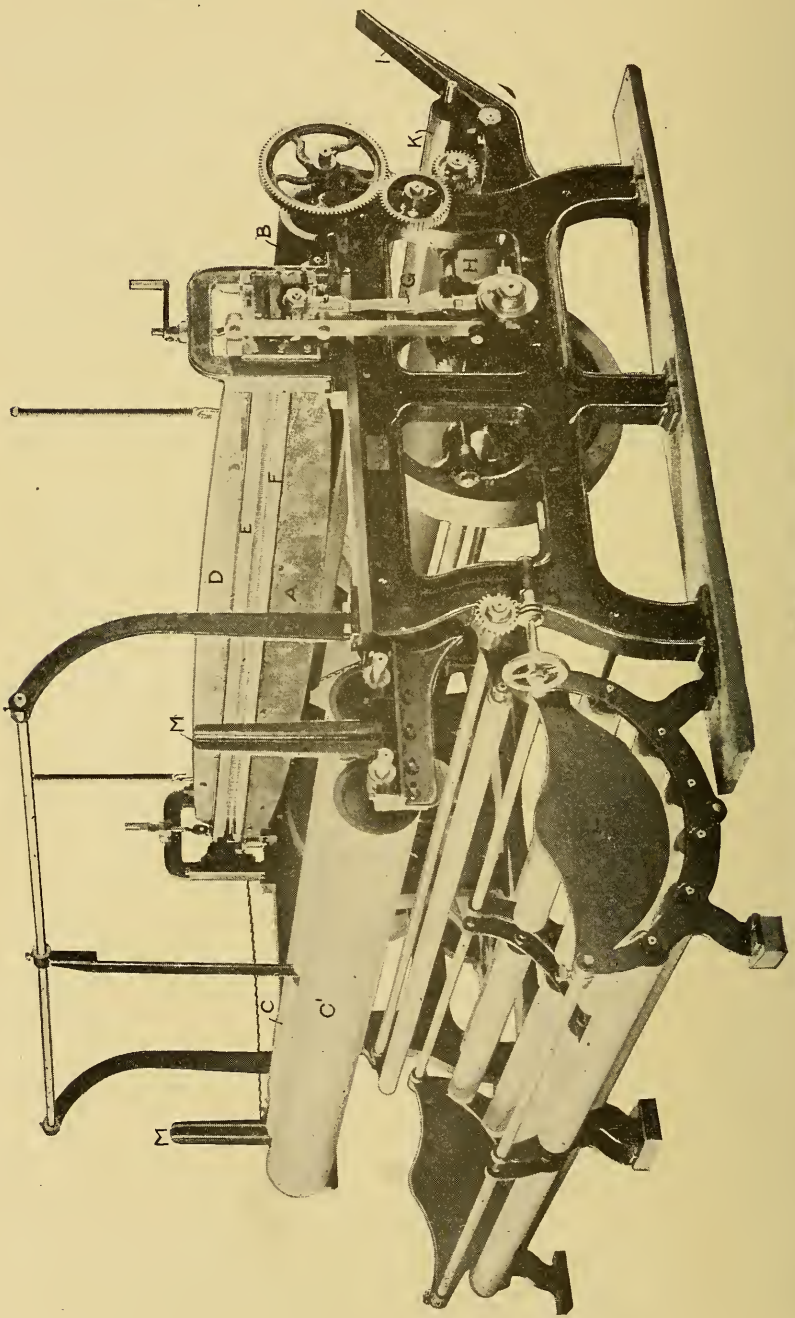


Fig. 7. Needle Punching Machine for Making Punched or Needle Felt.

punching mechanism proper. This latter part of the machine consists of the bed A and the head block D. The bed is rigid, but the head block is set into jaws on each side, to which, by means of the lever G, an up-and-down motion is imparted.

Into the head block D is fitted a board E, which is removable, and into which are set several rows of a peculiar kind of needle (shown in Fig. 8). As will be seen, these needles are supplied with barbs near the point which is intended to punch the stock into the burlap. They are set into the board very carefully and firmly, for in passing downward they pass between one-quarter inch steel rods F, set one-quarter inch apart. These rods are firmly placed one-half inch above the bed A, while the burlap with the carded wool stock passes over them; that is, between the rods and the head block D. It is necessary that these rods also be placed very carefully, for in the case of any deviation, the needles will come in contact with them and thus lose much of their efficiency. The needles are set in rows which are one-half inch apart and there is one-half inch space between the needles.

Fig. 8. Punching Needle.

The rolls B and C move the goods and are driven by a chain from the delivery roll so that their movement may be even and steady. A piece of burlap is fed into the machine at H, the piece being laid on the floor and taken up by the machine as it is needed. The bat of carded stock is placed at I, the end being passed under the roll K and placed on top of the burlap, and carried along with it. A leader is fastened to the end of the burlap and this is taken to C, usually passing over C and between C and C^1. From there it passes into the scray L.

The piece of burlap moves about one-quarter inch to each downward stroke of the head block D, and as there are five or six rows of needles, the stock is pretty thoroughly punched through it. When the bat of carded stock is run out, another is placed in position and the process continues, but when the end of the first forty yards (which is the length of the first bat) reaches the scray, it is cut off and returned to the front of the machine to await its turn for the next run.

As soon as the end of the second piece is reached, the first is

attached to its end, but in such a manner that the side which has been punched is on the underside. Another bat of carded stock is placed in position and the machine is again started. The burlap now receives a coating of wool stock on the other side. When the first end of this piece gets as far as the rolls C and C^1, it is separated from the other piece and wound around a stick which is placed in the slots, M M.

When the punching operation is completed the pieces are ready for the fulling. In the fulling room the pieces are first given a thorough soaping. It is desired to have the stock felted as well as it is possible to felt it, and as there is no danger of too much shrinkage, the soap for this kind of fabric can be made very strong in point of alkali. Of course, there is no grease to loosen which would require the presence of alkali in the soap to any extent, but on account of its being a great aid to felting it should be liberally used. The cost of alkali is much less than the cost of soap, and it has a tendency to make the body of the soap heavier, so that in this case the amount of hard soap to be used can be considerably reduced, thus keeping the cost for soap very low.

A soaping machine should be used on all felts, but it is a deplorable fact that this machine is found only in a few places. Without the aid of a soaping machine, the goods will have to be soaped in the old way by spreading them on the floor and applying the soap by means of a sprinkling can. The waste of soap thus entailed would soon pay for the best machine of this kind ever made, but when it is considered that almost any mechanic can construct a machine which will fill the need in every respect, it is surprising that so many still hold to the old way.

When the pieces have been properly soaped they may be placed in the fulling machine. In this instance also, the crank mills are preferable. The shrinkage will be small so that no particular attention is necessary in putting the pieces in the mill, as is the case on regular felt goods. However, if the stock has the felting property it should have, it is necessary to watch the pieces closely, and remove them from the machine frequently for an opening and general overhauling, so that no wrinkles may felt into them. Even though the goods are of the cheapest kind, they should be perfect.

The fulling proper should take about two hours and at the end

of this time the goods may be taken from the machine, well opened, and inspected.

The washing process is not very elaborate, as the pieces contain very little grease or other foreign matter which needs to be removed, but unless they are well rinsed they are apt to feel stiff at first. Plenty of warm water at the washer for these, as well as all other goods, is much to be desired. This does not mean that they cannot be washed properly without the aid of warm water, for unless the supply of warm water is plentiful it is as well to rinse entirely with cold water, bearing in mind, however, to let them rinse one-quarter or one-half hour longer than would be required with warm water.

From the washer the goods go at once to the dye house to be colored, usually a dark yellow. They are then ready for drying, if medium goods.

When a somewhat better quality of felt is made, it is given a heavy brushing with plenty of water. This has a tendency to lay all the loose fibers in one direction, but does not produce what may be termed a nap. When treated thus, the finished article has a much smoother and better appearance; but after a day's use, one would be unable to tell the better from the cheaper grade.

After drying the pieces they are taken to the press and receive a hard pressing, after which they are at once sent to the making-up room, for in most places the goods leave the mill in the shape of the finished blanket.

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